AIR FORCE JOURNAL of LOGISTICS

SUMMER

1981

AIR FORCE JOURNAL of LOGISTICS

AFRP 400-1

VOL V
NO 3

SUMMER
1981

AIR FORCE JOURNAL of LOGISTICS

CONTENTS

SPECIAL

ARTICLES

DEPARTMENTS

ITEMS OF INTEREST

Purpose The *Air Force Journal of Logistics* is a non-directive quarterly periodical published in accordance with AFR 5-1 to provide an open forum for presentation of research, ideas, issues and information of concern to professional Air Force logisticians and other interested personnel. Views expressed in the articles are those of the author and do not necessarily represent the established policy of the Department of Defense, the Department of the Air Force, the Air Force Logistics Management Center, or the organization where the author works.

Distribution Distribution within the Air Force is F through the PDO system based on requirements established for AFRP 400-1 on the basis of 1 copy for every 15 logistics officers, top three NCO's and professional level civilians assigned.

Subscription Subscription to the *Air Force Journal of Logistics* can be made for $6.00 per year domestic ($7.50 foreign) through the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Single copies are $2.00 domestic ($2.55 foreign). Back issues are not available.

Authority to publish this periodical automatically expires on 3 Aug 81 unless its continuance is authorized by the approving authority prior to that date.

A Rendezvous Building with the Soviet Union

General Bryce Poe, II
Commander
Air Force Logistics Command
Wright-Patterson AFB, Ohio 45433

(The following remarks were made by General Poe at a Tactical Air Command Logistics Dining-Out at Langley AFB, Virginia, on 30 May 1981.)

. . . I feel very much at home for several reasons. First of all, I have not been a logistician all my life . . . it just seems that way. In fact, I have more years in TAC than AFLC. Second, there is a special kindred spirit among logisticians—although the TAC version sometimes has a little different stripe and hue. Finally, part of my professional roots and heritage are here. I was flying the F-6D (photo Mustang to you uneducated) here when we got the first jets in 9th Air Force. Also, Langley joins with Wright-Patterson as a spawning ground for military aviation in this country. Billy Mitchell used this area as home base before his July, 1921, sinking of the *Ostfriesland*. Langley residents over the years have included such men as Spaatz, Eaker, Lemay, Quesada . . . and of course Bill Creech.

As many of you know, this will be my last chance to join you as AFLC Commander. My August retirement is one of the worst kept secrets. I am not sure how a retiring man's last words rank with a dying man's, but I hope it's in the ball park.

I don't plan to take you down memory lane tonight, but I do want to discuss some issues that concern and trouble me as I furl my flag and close the curtain on 38 years of military service. We in the Air Force have never been tied to the past. After all, we are much younger than the other services. (That's not to say that they are tied to the past either.) We have no Valley Forges or Shilohs or San Juan Hills to point to. Chateau-Thierry, Bastogne, Burma, Berlin and Khe Sanh will have to do. Many of our pioneers remain our contemporaries. And for that reason, we have the healthy tendency to look ahead instead of behind.

And yet foretelling the future has to be one of the most imprecise sciences of all. Anticipating problems has never been more important, yet we have never been very good at it. Back in 1929, President Hoover appointed a commission to plot the United States course through 1952. Over 500 researchers worked the problem. They studied and planned. They produced 13 volumes and a 1,600 page summary. Yet there was no mention of atomic energy, jet propulsion, antibiotics or transistors.

As late as 1937, Lord Rutherford, discoverer of the nucleus of the atom, said the idea of deriving atomic energy was "moonshine." In the 1960s, hardly a single biologist anticipated what would happen with DNA in 1973.

"We are engulfed in . . . change"

As we turn the spotlight on the future, we get that same nagging emptiness. Our powers of prediction are not likely to improve. In fact, they could grow worse. Events are happening too fast. We are engulfed in a roaring avalanche of change. A recent commentary said "the world may be going through the birth canal of a new age" . . . with all the signposts and landmarks unprecedented. What will be happening in space by the year 2025? Who will control the Persian Gulf or the Indonesian oil sources at that time? Or will we care . . . as we drive hydrogen-powered vehicles to work and board solar-powered aircraft? Where will genetic engineering take us? Will we literally "grow" our own pilots and engineers? Is surprise inevitable?

Those are weighty questions . . . questions that I can't answer and neither can you. The best we can do is cut the odds, hedge against surprise, reduce the variables. In that instance, I am convinced that the most important tool in our nation's future will be a strong, flexible defense.

That lays the burden on us, and meeting that challenge will not be easy. The keys will be a fundamental grasp of why we exist, a clear concept of who and what we are dealing with, a keen awareness of the obstacles in our path and a better handle on our priorities. That's what I want to talk about this evening—some of those keys to our future.

Refocus on Our Basic Mission

Why do we exist? It's an elementary question, but the answer seems to be growing a little obscure. Simply stated, it's to fly and fight and put missiles up and bombs down. Nothing more, nothing less. Everything else is secondary and subordinate.

There are a number of reasons for a loss of clarity on this issue in recent years. One is youth and experience. Look around you. Fully 40 percent of our officers are lieutenants. Over half of our enlisted force are 25 or younger. Almost 65 percent of our people came on active duty *after* we signed the peace treaty in Vietnam. It's been eight years since anyone fired a shot at us in a major conflict. We've had a busman's holiday!

Too many of our officers think of themselves as managers . . . rather than commanders and leaders.

We have become specialized, segmented, exclusive. Our highly skilled technicians tend to work alone or in small groups. There are fewer shared interests and experiences . . . to the point that it's tough for a computer operator, for example, to remember he or she belongs to a larger organization with a fundamental mission of flying and fighting. Senior officers go years without even a moment's reflection on principles of war—tools of our trade won across centuries at great cost in blood and treasure.

It's time we wake up and refocus on that basic mission. I know you are well aware of that in TAC. Your dramatic increase in sortie production and flying hours is proof of it.

We are placing the same emphasis in AFLC—measuring every effort against the necessity of meeting the needs of operational units. That's why our combat logistics support squadrons are so important—they can perform critical maintenance in the war zone when the chips are down and keep the flying units in the action.

That's the fundamental (and only) reason for our listening post teams. They were just here two weeks ago and we are hard at work on the problems you told us about. We are aware of our contract PMEL difficulties. We are taking a close look at depot support of your avionics intermediate shops—particularly in the F-15 area. Your other concerns with tech orders, greater visibility for item managers and proliferation of support equipment are already getting increased attention.

It has to be that way. If our efforts don't lead to greater support for you, we have failed . . . and failed in the only area that really matters.

No War of Ideas

For, in my opinion, sooner or later, we have a rendezvous building with the Soviet Union. Whether with them directly or their surrogates; whether it will be the plains of Germany or the sands of the Middle East or a final solution at the bargaining table; I can't say. But we need to recognize who and what we are dealing with. We are not locked in a war of ideas. They do not want to debate us. They want to subdue us . . . to neutralize our worldwide influence . . . to dictate terms . . . to at the very least Finlandize the western world.

We have won the ideological struggle . . . if indeed there was one. It was no contest. Look at the contradictions in Soviet society. Communism is in theory a paradise yet no one is fighting to get in and many risk their lives to get out. The Soviets need the educated man but cannot tolerate him . . . cannot offer the degree of liberty that produces far reaching, innovative results.

Economically, they have suffered serious reversals and appear headed toward prolonged stagnation and decline. They have not equaled the West in technology and productivity. If anything, the gap has widened. Their agriculture remains a disaster area.

They struggle to keep their East European satellites in line. The unrest in Poland is the bitterest pill of all. That conflict involves the suppression of the proletariat—the very class they theoretically sought to free.

Internationally, the communists are losing ground. In France, they won just 15.4 percent of the vote in the April 26 elections—far below their usual tally.

In Italy, the largest communist party in the West is losing ground for the first time in its history. In Spain, communist strength has topped out at 10 percent. In Portugal, they won only 16 percent of the vote last December and are growing more beleaguered in a rising conservative tide.

Elsewhere, are the Cubans better off today than under Batista? Ask the thousands who escaped and the many other thousands who want to leave. Are the South Vietnamese better off under the North Vietnamese? Ask the boat people. Are the Cambodians better off as Kampucheans? As one recent writer put it, ask the grave.

Only when they revert to their old formula of force, subversion or promise of aid do they make headway. Peter Drucker offered this description. He said the Soviets:

> . . . cannot accomplish new tasks, but only suppress problems, deny their existence, forbid their discussion. It cannot tolerate educated men, but it can breed technicians. It cannot create a society, but it can organize power. It cannot build international order, but it can exploit disorder.

What they *can* do, better than any thing else, is create military power . . . and in the last 20 years or so they have been imminently successful. Unfortunately, only in recent months have we begun to take serious notice.

Despite those massive Soviet gains, we seemed to sleep through the decade of the 70s. Only when the jagged edges of Soviet power and intent were exposed in Afghanistan did we begin to take notice.

Perhaps today, once and for all, we are seeing the shallowness of the so-called "ideological struggle." The truth is that we are dealing with a nation that Soviet dissident Sakharov described as "armed to the teeth" . . . a nation that has no regard for human dignity or rights . . . a nation that will take full advantage of reluctance or weakness.

They are well-equipped, well-armed and relentless. Their entree into Angola was not the *Communist Manifesto* but the barrel of a gun. No Afghans have been killed by abstractions.

In the biting words of columnist, John Roche, " . . . We of the democratic world are not threatened by a set of archaic, Victorian dogmas, but by men with guns who want power and probably couldn't distinguish Karl Marx from Groucho . . ."

Critical Resources and Rising Costs

Leonid Brezhnev reportedly gave a summary of Soviet intentions back in 1973. He said, "our aim is to gain control of the two great treasure houses on which the West depends: the energy treasure house of the Persian Gulf and the mineral treasure house of central and southern Africa."

You don't have to be a geopolitical scholar to fathom the impact of Soviet control over Persian Gulf oil and African mineral deposits. France draws 87 percent of its oil from the Middle East; Japan, 75 percent; the United Kingdom, 57 percent; West Germany, 34 percent; the United States, 14 percent. The third world dependence is almost absolute.

As for critical minerals, *we* are hurting.

First, *chrome*. Indispensable for stainless steel, ball bearings and surgical equipment. We have virtually no domestic supply. The world's reserves lie almost entirely in southern Africa—in South Africa and Zimbabwe, the former Rhodesia.

Cobalt. Essential to jet engines, machine tool bits and permanent magnets. We import 98 percent of our supply. Most from Zaire. Other major sources are Zambia, Cuba and the Soviet Union.

Manganese. Without it, you can't make steel at all. We import virtually all we use. South Africa has some 40 percent of the world's supply and the Soviet Union 50 percent.

Platinum. We import about 85 percent of what we use to manufacture catalytic converters and a variety of electronic and chemical products. South Africa holds 75 percent of the world's reserves; the Soviet Union the remainder.

The same can be said for titanium, asbestos and many other materials.

In short, we must wake up. A godless nation, with a third-rate economy, a shop-worn ideology and no respect for human rights and decency is positioning itself to shut the door on the western world. And we had better be ready if the bell rings.

"Being" or "getting" ready will be formidable. We can't do it in a vacuum. Forces largely or entirely beyond our control make the job more difficult.

One is rising costs—virtually out of control and getting worse. For example, the J33 engine we use on the T-33 aircraft cost us $21,000 a copy when we qualified the system back in 1947. Today, the F100 engine on the F-15 costs $1.9 million and $2.3 million on the F-16.

Second-stage fan blades for the C-5's TF39 engine (40 per engine) cost $772 each when we first bought them in 1968. By March of last year, the price had risen to $20,600—an increase of 2,668 percent. Through volume buying we have cut that to $16,000, but still the price is staggering, just like putting a 4-door Mercedes diesel at every notch on the wheel!

Another barometer of the times is the B-52 simulator which now costs about $25 million . . . not too expensive as simulators go. But that's not the entire story: $25 million is about four times what we were paying for the complete B-52 in the 1950s.

Other categories have leaped forward as well. In the past decade or so, depot maintenance expenses have skyrocketed: 154 percent for labor, 116 percent for material, 601 percent for utilities.

Aviation fuel has kept pace with the well known price rises in gasoline. From 1973 to 1979, fuel costs per flying hour jumped from $100 to over $500. Now, because of a more than 100 percent increase since last February, the cost is well above $1,300.

Another problem is reluctance to serve—particularly in operational and highly skilled areas. Our pilot retention is improving but we will still have a considerable shortfall through 1983. In fact, the shortfall is expected to be greater then than now.

The engineering shortage looks equally gloomy through 1983 and beyond. In AFLC, we have a 15 percent shortfall across the board—both civilian and military. The ones we have are sometimes double and triple tasked, undercutting morale, leaving little time to specialize and forcing some to serve where they are less qualified. Readiness suffers, responsiveness slows, people get discouraged and find some other place to work.

Even an influx of new engineering graduates would not immediately solve the dilemma since that would leave us with an equally serious experience problem. Nevertheless, I don't expect that influx right away. We simply cannot compete with starting salaries in private industry. For example, this spring petroleum engineers in some parts of the country are drawing starting salaries of $45,000 per year; chemical engineers are getting $30,000.

More fundamental is the long-standing American reluctance to adequately fund our defense requirements—particularly in peace time.

After last fall's elections and the apparent mandate to increase defense spending, it would be easy to believe all of our problems are going to disappear in a shower of money. Don't believe it! Short of a major threat to our lives and liberty, it has never happened . . . and probably never will!

Already the bets are being hedged. Hands have been put to the plow but heads are starting to turn in the wrong direction. The old "guns or butter" debate is being dusted off and discussed. Only this time, the "either—ors" are much more volatile: defense or food stamps . . . or unemployment compensation . . . or treatment for blacklung disease.

Even if the full range of proposals are passed, they hardly represent a windfall. The FY 82 total will consume only 5.8 percent of our gross national product, a level below most of the years in the 1950s and 60s.

Actions to Take

Moreover, every expenditure and management decision will be heavily scrutinized. Already, I am seeing a surge of articles on so-called DOD "waste, fraud and mismanagement." We may have to adopt policy used by several major department stores in the 1850s. They informed their sales clerks that "if they smoked Spanish cigars, got shaved in barber shops or danced at night, management would assume they were dishonest."

You laugh . . . but we had better be pure as the driven snow. Other agencies providing very worthwhile services employing people with very important jobs are going to be affected by any real increase in defense spending. And they and their constituents will be watching what we do very closely. We had better look at all decisions from every angle—an "alternate lifestyle" to some will be considered a sin by others.

In the meantime, there are a number of things we can do to make sure we get the most bombs on target for the buck. In systems development, we can't afford to sacrifice all other factors on the altar of performance. We have learned that lesson the hard way. Too often, our requirements are driven by what is technically achievable not by what is needed to meet a known or anticipated threat. Anybody who has been in a fight knows that how much gear you *have* is irrelevant . . . the big question is *how much of it works!* There are also a couple of old maxims you should remember: the part you never ask the designer for will never fail; the part you eliminate will never have to be replaced.

As for modifications, don't snub today's readiness for future "pie-in-the-sky." Be sure on the front end how much they cost, how much time they take and what resources they will consume. You must remember that every hour an aircraft sits in a hangar undergoing modification is an hour it neither contributes to deterrence or warfighting capability.

For example, as we meet here this evening, 12.5 percent of the F-4 force is down for maintenance or modification. Give those aircraft an 80 percent OR rate, surge them to two sorties a day, load wall-to-wall Mark 82s and you can put 1,300 tons of bombs on target each day. I don't mean to stop Pave Spike, ALE 40, APX 80 and others . . . but remember the penalty . . . count the *real* cost.

As you can see, all of these are unfinished agendas. They will yield only to your best efforts and strong dedication.

Philosopher Peter Drucker recently summarized pretty well all that I have said. He wrote:

> A time like this is not comfortable, secure, lazy. It is a time when tides of history over which we have no control sweep over the individual. Every one must be ready to take over alone and without notice and show himself saint or hero, villian or coward. The great roles are played out in one's daily life, in one's citizenship, in one's courage to stick to an unpopular principle. . .

Finally he said:

> In a time of change and challenge, the individual is both all-powerless and all-powerful. He is powerless, however exalted his station, if he believes that he can impose his will, that he can command the tides of history. He is all-powerful, no matter how lowly, if he shows himself to be responsible.

Thank you.

(At press time, General Poe had been nominated by President Reagan to the retired list at his present four-star grade effective 1 August 1981. Lieutenant General James P. Mullins, commander of SAC's 15th Air Force, has been nominated to succeed General Poe as Commander, Air Force Logistics Command.)

USAF LOGISTICS POLICY INSIGHT

Program Management Directive for WRM Requirements Improvement

Numerous efforts are in process to improve systems for WRM requirements development, programming, buy and allocation. An AF/LE PMD was published on 8 Apr 81 to serve as a mechanism for organizing, prioritizing, and coordinating improvement efforts. Program management plans are now being developed by responsible OPRs. The process of prioritization should assist in focusing limited resources into most important areas.

Harvest Bare Technical Improvement Efforts

In January of this year the Harvest Bare Technical Improvement/Enhancement Conference was convened at Holloman AFB, New Mexico, in order to identify solutions and initiate corrective actions on known deficiencies existing in the equipment and facilities. There has been increased emphasis on the enhancement of bare base equipment due to the lack of a logistic infrastructure in Southwest Asia. Operation from bare bases in this harsh and hostile environment requires resources to perform aircraft maintenance and provide housekeeping support. Special resources are needed to offset the environmental extremes in this region, e.g., dust, sand, windstorms and temperatures that range from 20°F to 130°F. The next program review, scheduled for July 1981, will address the status of identified action items.

Changes in Multi-year Procurement Restrictions

Multi-year procurement has become a popular subject of discussion among members of Congress, their staffs, OSD, OMB and the Secretariat. Certain constraints imposed by statute and full-funding policy have prohibited the Air Force from realizing the full potential offered by multi-year procurement techniques. It appears very likely that several of the existing constraints will be relieved to some extent. Particularly promising are the prospects of being able to include recurring costs and the increase of the cancellation ceiling from $5 million to $50 million. With regard to these welcomed changes the Air Force is especially optimistic in the application of multi-year procurement to logistics support operations. As soon as Congress reacts to the current proposals, new procurement guidelines will be made available (if necessary) through appropriate channels.

Service Engineering/ Software Support by Contract

The Air Force is currently faced with critical service engineering/software support funding shortfalls in the Operation and Maintenance (O&M) appropriation. This situation results from an inability to convince OSD/OMB and the Congress of the need to increase funding above the present levels. Less than 50% of service engineering/software support requirements are funded in the Five Year Defense Program (FYDP), and this percentage will probably decrease due to continuing strong Congressional objections to the use of Personal Services Contracts. To reverse this trend, AFLC/LOE has been asked to undertake a thorough review of policies and to prepare a comprehensive briefing which shows that service engineering/software support by contract is necessary and is based on an examination of requirements and costs.

Additional Cost Comparison Studies of Logistics Operations

The Office of Management and Budget (OMB) in an 8 April 81 letter to the Secretary of Defense (SECDEF) emphasized that a major goal of the Reagan Administration is to maximize the efficient expenditure of funds and that OMB Circular A-76 is a necessary tool for meeting this goal. The Circular provides that, when contractor performance is feasible and no overriding factors require in-house performance, a cost comparison of contract costs versus in-house costs will be accomplished to determine which method will be utilized as most economical. The OMB letter requested that the SECDEF schedule four functions for cost comparison studies in fiscal years 1981–1982. Of particular interest to the Air Force logistics community is the inclusion of Supply and Industrial Depot Maintenance Support Operations based on the assumption that depot industrial fund personnel are performing support type functions (i.e., equipment maintenance, facilities maintenance, custodial, etc.).

New Supply Support System for Civil Engineering

Currently, the Air Force uses a variety of systems to provide supply support to Civil Engineering activities. Approximately 47 bases use the Contractor Operated Civil Engineering Supply Store (COCESS) concept whereby a contractor establishes a supply store on base and issues materials to Civil Engineering on a contracted basis. Other methods of supply support include: A Government Operating Civil Engineering Supply Store (GOCESS) concept where in-service personnel operate and replenish the store; and the Base Supply support concept where the same computer supply system that supports the aircraft operations provides Civil Engineering support.

The Air Force is considering a uniform worldwide supply support system for Civil Engineering support. This system will be government controlled, dependent on uncomplicated user input/output, will take advantage of state-of-the-art computer systems, and will directly access, interface, and rely on existing commercial support practices. Air Force plans on prototyping the system in late 1982 with implementation in 1983. This is an initial effort to develop a supply system tailored to a particular functional area. After implementation, other functional areas will be reviewed for possible system development.

Increased Release Valuation of Personal Property

The adequacy of the household goods carrier liability of 60 cents per pound per article has been questioned as to providing reasonable coverage and protection (against loss or damage) for Air Force-sponsored personal property shipments. In an attempt to resolve this issue while providing its members improved service, the Air Force is preparing to test procedures allowing for increased valuation on personal property shipments. Carriers will be liable for the full replacement cost (less depreciation) or repair cost on those items lost or damaged in shipment, up to a maximum liability of $1.25 times the actual weight of the shipment. The test program, titled "PROJECT REVAL," is scheduled to run for six months beginning this summer, and will involve Air Force-sponsored personal property shipments originating from and terminating in one of the 48 contiguous states. The test will determine the benefits to be derived from the increased valuation of DOD-sponsored personal property shipments, both for the individual member and government. Air Force personnel will be given an opportunity to participate in "PROJECT REVAL" at the time of their household goods counseling through their local Traffic Management Office.

Control of Contractor Access to GFM

DODI 4140.48, "Control of Access to DOD Material Inventories by Maintenance Contractors," was published 13 Mar 1981 in response to OSD direction that the services/agencies develop policy to standardize procedures for furnishing Government Furnished Materiel (GFM) to firms performing work on maintenance contracts.

The instruction authorizes each DOD component to establish one or more Management Control Agencies (MCA's) to maintain central control over all contractor access to the DOD supply system. All contractor GFM requisitions will be routed through MCA for validation and approval prior to being forwarded to the appropriate DOD source of supply.

Test of GFM Sales Concept

Authority to sell government property to contractors performing work on maintenance contracts rather than furnishing materiel as Government Furnished Materiel (GFM) is now Public Law (Sec 767, PL 96-154). Implementation of the sales concept will motivate maintenance contractors to order only essential materiel and will reduce records required for management of GFM in the contractor's possession. Air Force is using four contracts to test the sales concept. Two bids, one with GFM and one with purchased material, are being requested on these contracts. The first contract award is anticipated in mid-1981.

MOLO: A Concept for Rapid Deployment Joint Task Force Logistics Control

Garry L. Waters
Chief, Financial Management and Analysis Branch
Resource Management Division
San Antonio Air Logistics Center
Kelly AFB, Texas 78241

Editor's Note: The operative word in the title of this article is "concept." The article does not provide, nor was it written to provide, a final answer to or even a complete analysis of the issues examined. It does reflect the type of conceptual thinking that often precedes and, to whatever extent it is proven valid, sometimes shapes the full development and implementation of alternative solutions to complex problems. In this case, the author has conceptualized a means to meet one of the most critical logistics challenges the American military faces: providing timely logistics support, on a global basis, to combat engaged units.

As is often the case with new concepts, the one in this article depends on capabilities that have been not only unavailable but unattainable in the past and possibly will remain out of reach in the immediate future. But new capabilities and new technologies do arise, and old ones are improved, not least because someone clearly stated the need for such changes to occur. Coincidently, in the areas on which the feasibility of the concept in this article would depend, automated data processing and communications, new developments have been occurring at a phenomenal rate in recent years and give every indication of continuing to do so in the future. Who can incontrovertibly state that the ADP data base and communications link-ups necessary for the mobile logistics unit (MOLO) concept to work will not be available, say, within the next decade or two? Certainly the need addressed by the concept must be met whether a MOLO in some form exists or not.

Many military logisticians will recognize that some of the operations and procedures described in this article could, if implemented in toto, run counter to current policies. Policies, too, like deficient capabilities, dwell in the realm of surmountable obstacles. They can be changed. Most inevitably are.

At the very least, a periodic jabbing of existing policies helps prevent bureaucratic ossification and military inflexibility. The MOLO or any other new concept, even if inherently impractical as initially conceived, will have served as a useful purpose if it helps flag those policy areas needing the next jab.

In "A Concept for Modern Military Logistics," Colonel Fred Gluck, USAF (Ret.), wrote:

> The present operation of military logistics within the Defense establishment is at best marginally effective . . . . The ultimate result . . . has been reduced responsiveness, increased costs, and a lower availability of operational weapons for combat. This overall situation is caused by a failure to 'gear' military logistics . . . to effectively meet the needs of the Twentieth Century military environment (2:14).

Two currently prominent features of the 20th century military environment created by this country for operations beyond its borders are the Joint Deployment Agency (JDA) and the Rapid Deployment Joint Task Force (RDJTF). As recent developments, they are still "gearing" their logistics to the 20th century. While we should and do plan for 30, 60, or 90 days initial logistic support, a system must be devised to allow early changes to the plan based on direct battlefield inputs. To accomplish this, I propose that a mobile unit be established to handle intercountry and intracountry logistics, on an exception basis, as the battlefield needs dictate. The unit should have joint service logistical experts with communications and ADP on-scene to receive logistic requests direct from battlefield unit commanders. The mobile logistics unit (MOLO), with direction from the COMRDJTF, would allocate airlift and sealift resources for priority material movements. It could also retransmit requests via satellite direct to CONUS, with shipping instructions. This unit with its intrinsic ADP capabilities would monitor the total logistics system, both intercountry and intracountry. This monitoring would include the capability to divert resources from one water/aerial port to another if necessary because of enemy activity, saturation of the port or battlefield requirements.

The MOLO should have the capability to move to the battlefield on short notice as a complete unit. This would allow the COMRDJTF to begin identifying unplanned priority-sensitive resupply that needs special handling. The MOLO—with its organic computer and communications—would start (1) accepting priority requests from battlefield commanders, (2) changing priorities and modes of transportation for critical supplies, (3) tracking supplies enroute to the task force, and (4) monitoring all stockpiles within the area.

Battlefield commanders could request supplies via radio, telephone, or even messenger, if necessary. After receiving a supply request from the battlefield commander, the MOLO would check all the local supply stockpiles, e.g., shipboard, War Readiness Spares Kit (WRSK), or pre-positioned. If the supplies were not available locally, the MOLO could check its computer to see if the parts were enroute. If enroute, the MOLO would have the estimated date and location for arrival. And if the item was not ordered—or was not due into the area sooner than the time necessary to airlift it from another source, either CONUS or a WRM stockpile elsewhere in the world—then the item would be a candidate for special handling. If the candidate for special handling is an item that is, in fact, critical to the mission—based on the task force commander's current needs and guidance—then it would receive special handling by the MOLO, which would force the item into the airlift flow from the fastest source possible. A diagram of this decision process is shown in Figure 1. With this system, the task force commander has both the information and the capability necessary to have a direct real-time influence on supplies that he believes are critical to the mission.

Setting priorities of supplies and making the decision necessary to insure that transportation assets, especially airlift, are used with maximum efficiency would be a responsibility of the MOLO. However, maximum efficiency of the units employed on the battlefield can often be obtained only if the task force commander has a real-time influence on supplies, which is why the MOLO needs to be under the task force commander's direct control and why the MOLO concept needs to be established. The mobile logistics unit could not only change modes of transportation for supplies coming into the theater, but it could also change the destinations of ships and aircraft enroute if the battle lines or port availability dictated that such a change was necessary. Please note that the mobile logistics unit's ADP is an absolute necessity for creating the traffic management capability identified by Vice Admiral Thomas R. Weschler as essential for effective theater logistics.

> Traffic management is a key to effective theater logistics. It is a direct responsibility of the unified commander. Having this responsibility, he should be accorded the authority however he may implement it. Traffic management refers not only to what enters each overseas port or airhead and the priority or degree of offloading there, but also to the forecasting of what can be handled and where, the diversion from one point to another, the collection of retrograde, and the changes in priorities. When necessary, it may reach as far back as the air or seaport of embarkation in CONUS to dictate special loading of aircraft or ships, diversion or speedup and, when containers are used, even to the supply points or factories. This last point with containers is to control stuffing to suit theater optimized handling.
>
> The Theater commander must have complete knowledge of all ports [air and sea] in his theater, including information on their [seaports] ability to offload nonself-sustaining container ships, to store containers, to load them on trains or barges, and to unstuff or stuff cargo in them (6:24-25).

Port availability and capability have to be monitored constantly to minimize delays of vital supplies due to effects of enemy activity or port overload. This monitoring must be done while getting the supplies as far forward as possible with a minimum number of transportation mode changes.

The tracking of supplies by the MOLO would aid in making the decisions necessary to get the most important supplies on-scene first. Tracking also would allow the battlefield and task force commanders to know when their supplies will arrive. In country, this tracking would include monitoring the entire transportation system to route supplies from the ports to the frontlines as fast as possible. In places where contracting for inland transportation is a possibility, the MOLO could also handle routing and scheduling of contractual inland transportation.

The monitoring of stockpiles in the area by the MOLO unit would allow the service's stockpiles to help the other services whenever possible. Also the MOLO, by automatically monitoring stock levels and consumption, could reorder stock using the basis of past consumption to determine minimum amounts needed to be ordered. This complete in-theater supply integration is a capability presently denied to the task force commander, a capability which could mean the difference between flying a Navy F-4 or not, by using parts from an Air Force spares kit that is already on-scene or it could mean a critical Air Force M-818 being returned to service because the Army had the parts to fix the truck and the parts were on-hand. A good spinoff feature of such an on-scene ADP capability would be to monitor costing for later reimbursement or repayment as required. The MOLO will be a way we can achieve the most effective battlefield resupply with limited transportation assets.

Assuming that this concept meets the criteria of suitability, feasibility, and acceptability, I would suggest that the United States needs to start establishing a MOLO. Almost all of the items the MOLO needs are within today's state of the art. Of course, the mobile computer is the heart of the MOLO concept, and both the Air Force (using a Univac 1050-II) and the Army (using an IBM 360-30) have mobile computer systems. To be considered mobile, a computer system must (1) have its own power and environment; (2) be able to be delivered via truck, rail, or air; (3) be in operation within six hours of arrival (4:53). The Air Force used this basic technique for supply interface between the United States and Vietnam and had an on-scene mobile computer to relay supply requests via satellite back to CONUS. This computer-to-computer interface via satellite allowed the supply "pipeline" time from CONUS to the war to be shortened from weeks to days (4:52-54).

MOLO and a Strategic Logistics Agency

The MOLO should be "joint-staffed" with personnel from all services. There are several ways of looking at the MOLO structure. One way would be a direct interface with the Joint Deployment Agency which is already tasked to coordinate notional resupply requirements with actual data in the Time-Phased Force Deployment Data base. An alternative, using Admiral Weschler's suggestions concerning on-scene logistics, in general, as a basis for the MOLO, would be for REDCOM to be the CONUS agent and the supply interface for the theater commander in terms of retrograde and resupply. Mesh that idea with a unit similar to the Strategic Logistics Command suggested by Brigadier General Winfield Scott, USA (Ret.), but with less responsibility (5:68-75), and you have the organization I believe could do the joint task force resupply and supply buildup best. REDCOM would be the overall command with the Strategic Logistics Agency as a subordinate unit. The Strategic Logistics Agency would establish a CONUS center to receive the data and communications from the MOLO (again building on the JDA is an obvious alternative). This agency should have access to all three services' supply systems, to DLA, or direct to manufacturers of war materials, if necessary, with authority to use the fastest means possible to obtain and ship the needed war supplies.

The Strategic Logistics Agency would also have the responsibility to review the logistic annexes for all joint plans. This review would insure that the United States could logistically handle the one and one-half war scenario the military is required to plan for. In this respect the Strategic Logistics Agency could do a job within the broader logistics arena similar to what the Joint Transportation Agency does within the transportation area.

A subject this paper does not address but one that should be looked at in the future is General William G. Moore's "concern with the lack of a system to collectively produce movement demands for supplies and munitions . . . of an OPLAN" (1:2). However, as Lieutenant Colonel Lawrence J. Faessler, USAF, pointed out,

> The means of developing real resupply data is at the heart of the issue . . . there is a very definite need for a near exact correlation between the TPFDD [Time-Phased Force Deployment Data] resupply record and actual supplies requiring movement. If the TPFDD record reflects 300 short tons of munitions requiring movement from Wright-Patterson AFB, Ohio, to Ramstein, Germany, there must be a degree of assurance that the munitions do exist, other than notionally on a JOPS [Joint Operation Planning System] TPFDD record, and that they are at Wright-Patterson. The way to

> accomplish this is to manually intervene in the JOPS process by replacing the MRG [Movement Requirements Generator] calculated supply requirements for at least the first 30 days and interject actual supply/munitions movement requirements developed by the agencies responsibile for their management . . . . By employing this technique the most valid supply availability information will be introduced at the level where it is managed (1:3).

Even though I have not fully analyzed this issue, I believe this is another area the Strategic Logistics Agency could address.

Just as we would be smart to set up both the MOLO and the Strategic Logistics Agency, we need to continue to be smart and learn from past mistakes while implementing this system. Yes, it is a system and should be managed by a System Program Office established to ensure that hardware, programs, and interface are entirely compatible. While the systems approach is absolutely necessary, even more important is the need for a long-term commitment by the Systems Project Officer. According to Captain Stephen R. Ruth, SC, USN (Ret.), the lack of understanding the need for this long-term commitment by the Air Force and the subsequent continual replacement of the project officer contributed to the demise of the Advanced Logistics System (ALS). He went on the say,

> In the case of ALS, as well as many other data systems in DOD, the responsibility for the various difficulties encountered is shared by many but held by none. The management of the project shifted hands many times over its life. The net effect was a series of caretakers who had responsibility but not necessarily accountability for their work . . . . What is needed is an executive team which is responsible enough for long enough to take charge and manage a project, not preside over it for a time. It would seem almost a necessity that the senior military or civilian leader appointed to the next large system effort have the understanding that the job involves a long-term commitment.
>
> This implies some kind of assurance to military and civilian senior members of a competitive opportunity for appropriate promotions as time elapses without leaving the project. The short-term manager is not appropriate (3:11).

Therefore, we need not only a dedicated Systems Programs Office but also a long-term committed project officer.

While this paper does not address the feasibility and acceptability of the MOLO concept, I believe that this concept could be the start of a solution to an enormous problem; for the battlefield commander on the end of a 5,000 mile logistics pipeline it may be the only answer. It would allow him to have the control necessary to ensure that he has what he needs when he needs it. No battle should ever be lost for want of a nail, especially if the nail did not arrive because the OPLAN did not anticipate that it would need to be replaced yet. To be successful the task force commander must have real-world control of his supplies and the MOLO concept can give this to him. In fact, it could mean the difference between success and failure of his mission.

References

[1] Faessler, Lawrence J., Lt Col, USAF. "JOPS and Resupply: The Connection." *Air Force Journal of Logistics,* Vol. IV, No 2 (Spring 80), 2-3.

[2] Gluck, Fred, Col, USAF (Ret.). "A Concept of Modern Military Logistics." *Logistics Spectrum,* Vol. 13 (Winter 79), 14-18.

[3] Ruth, Stephen R., Capt, USN (Ret.). "An Idea Whose Time Had Not Arrived." *Navy Supply Corps Newsletter,* Vol. 41 (August 78), 8-11.

[4] Ryan, John D., Gen, USAF (Ret.). "The USAF Support Team: Tonkin to Linebacker." *Air Force,* Vol. 56 (May 73), 52-54.

[5] Scott, Winfield S., Brig Gen, USA (Ret.). "A Strategic Logistics Force." *Strategic Review,* Vol. 4 (Fall 1976), 68-75.

[6] Weschler, Thomas R., Vice Adm, USN (Ret.). "Priorities and Emphases for Logistics, 1976-78." *Naval War College* Review, Vol. 29 (Summer 76), 16-29.

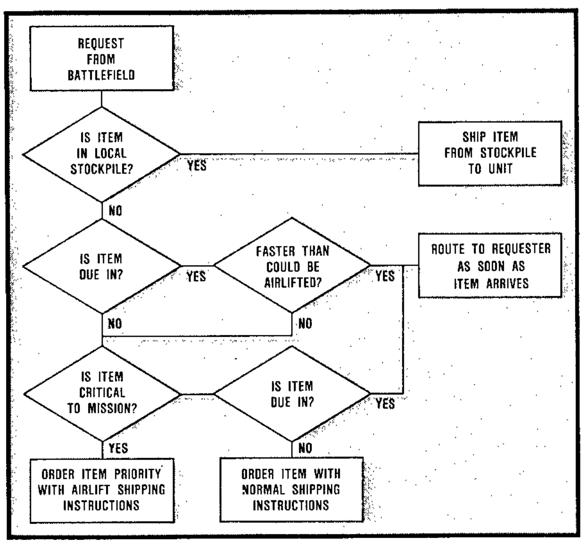


Figure 1.
MOLO Logistics Handling Decision Process

Career and Personnel Information

The Affect of DOPMA on Promotions

Today, the most asked question at MPC, especially from reserve officers, is, "How will DOPMA affect my promotions?" Our answer, of course, varies on a case-by-case basis. Most officers will see no drastic change. However, some officers will be dramatically affected and will soon face major career decisions.

The primary impact of the Defense Officer Personnel Management Act (DOPMA) on officer promotions is the creation of a single promotion system. Prior to DOPMA, regular and reserve officers had to compete twice for promotion to the same grade—temporary and permanent. However, regular officers were not subject to separation or retirement until they had been twice deferred to their permanent grade. Of course, this provided additional promotion considerations under the temporary promotion system for regular officers. Under DOPMA, regular and active promotions will be permanent with promotion opportunity (quotas) and phase points (pin-on) essentially the same as today's temporary promotion system.

DOPMA, as passed by Congress, did *not* include a mandatory all-regular career force provision although the services were encouraged (and the Air Force goal remains) to work toward an all-regular career force by policy. (Career force here meaning field grade officers.) To transition our current career force, which has both regular and reserve officers, the Air Force will convene a "catch-up" board to augment reserve officers into the regular force. This board will be held in conjunction with the permanent major board, meeting 13 Jul 81. All reserve lieutenant colonels in the 62, 63, and 64 year groups who have not failed temporary or permanent promotion to the next higher grade will be considered for augmentation. Reserve majors in the 67 and 68 year groups will also be considered. Selection will be on fully qualified basis which means the board could augment all eligibles. Although 100 percent augmentation is unlikely, selection rates should be high. This gives selected officers a significant potential increase in their tenure. For example, reserve lieutenant colonels have a maximum of 20 years commissioned service while regular lieutenant colonels have 28 years. Reserve officers will not be forced to accept the regular commission. However, those who desire to retain the option of remaining past 20 years should carefully consider the advantages of regular status.

Currently, the Air Force limits reserve officers to a maximum of 20 years active miliary service *or* until they are eligible to retire as an officer (whichever is later). This policy forced many reserve officers with extensive enlisted service to retire before competing for promotion to major. Effective immediatey, these officers will have an opportunity for two considerations for promotion to major prior to mandatory retirement. If selected for major, they will automatically be offered a regular commission if otherwise eligible.

The status of regular officers who have been deferred for permanent promotion must also be resolved to complete the transition to a single promotion system. To do this, the Air Force will convene a special promotion board in January 1982 to consider all regular officers once deferred to captain, major or lieutenant colonel. These officers will either be promoted, involuntarily separated, retired if eligible, or selectively continued. Regular officers who have been twice deferred to the next higher permanent grade prior to DOPMA implementation (15 Sep 81) will be considered for continuation by the 15 Sep 81 continuation board. If not selected for continuation, they will be retired (if eligible) or separated.

The Regular/Reserve Mix

Once DOPMA is implemented, our officer force will still have regular and reserve officers. Our personnel management policy will be to bring most officers in as reservists (except academy graduates) then consider them for regular augmentation when promoted to captain and at the five and seven year points. All officers selected for major or above will be offered a regular commission.

Under DOPMA, all promotions will be permanent. Officers twice deferred to major or lieutenant colonel *could* be involuntarily separated which is essentially the same as the current permanent promotion system. The current system, however, does not consider officers for permanent regular lieutenant colonel until the 19th or 20th year of service. Therefore, most of these officers are retirement eligible, or in retirement sanctuary. With DOPMA, officers will be considered for permanent lieutenant colonel earlier and most of those officers deferred will not be eligible for retirement. However, Air Force policy is to continue these officers until they are retirement eligible. There will be no forced attrition short of retirement eligibility for officers twice failed to lieutenant colonel.

In addition, DOPMA permits *selective* continuation of majors twice deferred to lieutenant colonel to up to a maximum of 24 years active commissioned service to meet Air Force needs. Captains twice deferred to major may be selectively continued up to 20 years active commissioned service. Continued officers would remain eligible for promotion. Individuals declining continuation will be entitled to separation pay if otherwise eligible.

After years of debate, committee meetings and hard work by DoD and Congress, DOPMA will finally become a reality on 15 Sep 81. In its entirety, DOPMA deals with issues and policies across the officer personnel management spectrum. Here we have only covered its promotion and augmentation implications.

For officer promotions, DOPMA means a more efficient, single promotion system that maintains force management flexibility and officer promotion opportunities. The new permanent grade tables in DOPMA eliminate the need for the Air Force to periodically request temporary grade relief and allow the stability in promotion planning that is essential to provide predictable and adequate career progression opportunities. DOPMA is truly a milestone in military personnel management.

(Major Russell Weaver, Supply Career Management Staff Officer, HQ AFMPC/MPCROS1E. *Major Weaver has had a key role in sustaining the quality of information in this department from its inception.)*

Centralized Civilian Career Management

The Logistics Civilian Career Enhancement Program (LCCEP) is the first completely automated, centrally managed civilian career program established in the Air Force. Others will follow in the future. The directive outlining this program is AFR 40-110, Vol IV, 18 Oct 79. The LCCEP was implemented on 1 Oct 80 with the announced selection of a Logistics Executive Cadre of 560 employees at the GS-11 through GS-15 grade levels from an inventory registration of 8,906. Since implementation, there have been over 89 position vacancies filled at the GS-12 through GS-15 grade levels by both Cadre and inventory members.

The program is managed by a PALACE Team of logisticians, personnelists, and administrative personnel in the Logistics Career Program Branch, Career Management Division, Office of Civilian Personnel Operations (OCPO), Randolph AFB TX. The program receives policy guidance and direction from a Policy Council co-chaired by Mr. Lloyd K. Mosemann, II, Deputy Assistant Secretary of the Air Force (Logistics), and Lt Gen Billy M. Minter, DCS/Logistics and Engineering, HQ USAF. The Council has membership composed of senior civilian and military logisticians representing some of the major commands (MAJCOMs) with heaviest civilian employee representation in the logistics function.

Recent discussions with employees and managers revealed some misconceptions on how the program functioned. Some of these concerns were:

Misconception: That selection of an employee for a program position was accomplished centrally and not by local supervisors/managers.

Fact: A certificate of the most highly qualified candidates who are registered in the program is provided to local management for their selection action. Up to 10 candidates are referred on a certificate. An exception to this is for a selected few career broadening positions which are filled through an Air Force Panel interview.

Misconception: That the Logistics Executive Cadre is an elite group who are the "annointed ones" and will receive all of the promotions in the program.

Fact: There are 560 members in the Cadre. Competition was keen with 5,896 registrants competing and 2,140 interviewed and ranked by MAJCOM Interview Panels. Tenure in the Cadre is 3 years with a new group selected each year. After 3 years, Cadre members must compete again for selection. Total size of the Cadre is based on the annual projected vacancies in program executive positions. Cadre members receive primary consideration on 705 positions designated Cadre Reserved. Other registrants are considered on these positions when there are not sufficient Cadre members to be referred. Registrants also receive consideration on 428 Career Essential positions.

Misconception: That logisticians in the OCPO PALACE Team deal directly with the Cadre members, sending them lists of long-term training possibilities and telling them to develop an Individual Development Plan (IDP) for these courses and then obtain signature of the supervisor.

Fact: AFR 40-110, Vol IV, specifies that the PALACE Team in OCPO will provide career advisory service to Cadre members which includes assistance in completing the IDP (AF Form 2674). Master Development Plans are included in this regulation which outlines recommended training for all logisticians GS-1 through GS-15. An IDP must be approved by the individual's immediate supervisor and higher-level management to insure that they agree that the training projected is necessary for career development of the employee.

Misconception: That Promotion Evaluation Patterns (PEPs) favor academic degrees.

Fact: There are no academic requirements in an PEP used on LCCEP positions. A career brief is provided on each candidate referred on a certificate which reflects that candidate's academic achievement level but is not a ranking factor on a PEP.

To clarify these misconceptions and to set forth the facts, Mr. Mosemann recently presented program status briefings at several installations with a heavy concentration of program participants and will give future briefings at other selected locations.

LCCEP Activity

1 Oct 80 - 31 May 81

	Cadre Reserved	*Career Essential*
Certificates Issued	51	38
Selections:		
Cadre	41	7
Non-Cadre	3	19
Outstanding Certificates	8	11
Promotions	37	24
Lateral Reassignments	7	2

Vacancies By Grade:

GS-12	*GS-13*	*GS-14*	*GS-15*	*Total*
24	24	29	12	89

EEO Data:

Referrals:	629	Selections:	70
Male:	588 (93%)	Male:	63 (90%)
Female:	41 (7%)	Female:	7 (10%)

Source: OCPO/MPKCL, Randolph AFB, Texas (Autovon 487-4087)

AFLC to test Assigning Senior NCOs As Assistant Weapons Systems Managers

Air Force Logistics Command has approved a test program to assign senior maintenance noncommissioned officers from the operating commands to AFLC system manager offices.

The test will begin at Sacramento Air Logistics Center, McClellan AFB, Calif., possibly as early as August. AFLC has requested Tactical Air Command and Strategic Air Command to assign a maintenance NCO, in the rank of master sergeant through chief master sergeant, to key positions as assistant weapons systems managers at Sacramento.

The purpose of assigning highly qualified maintenance NCOs with recent field experience is to improve communications between the weapons systems managers and the biggest users of those systems, the operating commands.

Because squadron level operations and maintenance performance is the final measure of system effectiveness, the system manager has a real need for someone with "hands on" maintenance experience at the operating base level. The new assignments are expected to fill that role.

In a message to SAC, MAC, and TAC, Gen. Bryce Poe II, AFLC commander, suggested the placement of "senior experienced maintenance personnel, knowledgable of weapons systems and field problems, in the system managers' offices." General Poe cited the following advantages to this procedure:

First, the communication between the system managers and operational units would be vastly improved.

Second, the positions would provide some senior NCOs with beneficial and unique weapons systems experience.

Third, the manpower resources and the newly assigned NCOs would still be controlled by the operating command and could be easily substituted or withdrawn if necessary.

The new senior NCO position will be used to provide improved communications with maintenance and supply managers in the operating commands, system managers at major command level, program managers in the Air Force Systems Command, Air Staff, and with item managers, equipment specialists and engineers at the air logistic centers, and Defense Logistics Agency supply centers.

The weapon systems at Sacramento ALC that the new assistant weapon system managers will be assigned to are the FB-111 (SAC) and the F-111 or A-10 (TAC). (LOGNEWS 81-152)

Item of Interest

Occupational Survey of Air Force Transportation Officers and Civilians Scheduled for this Fall

The transportation career field is in a state of change brought about by new trends in the environment. Economic constraints, strategic mobility, rapid deployment initiatives, and the increasing use of civilians and contractors in formerly military roles will challenge the career field in the 1980's. The Air Force Transportation Community can ease these changes by insuring its personnel are efficiently and effectively classified, trained, and utilized. To assist in this critical undertaking the USAF Occupational Measurement Center (OMC) at Randolph AFB, recently completed an occupational survey of the enlisted Transportation specialties (AFS 60XXX). To complete an overall examination of the field, HQ USAF/LET and SAF/ALG have asked OMC to conduct an occupational survey of Transportation Officers and equivalent grade Air Force civilians.

The occupational survey is designed to identify the tasks performed by officer level transporters, identify job groups in the career field, determine tasks requiring emphasis in formal training, and examine how tasks performed vary as a function of paygrade, MAJCOM assignment, organizational level, and time in the service. The data are very valuable to training personnel and career field monitors in fine-tuning the training, classification, assignment, and utilization of transporters.

Early Preparations

The Transportation Officer survey ws initiated in January 1981. Transportation specialists from the Air Staff, the various MAJCOMs, and special activities, such as the AF Data Systems Design Center and AF Logistics Management Center, met at Randolph to discuss how to best conduct the survey. Workshop participants identified the major functions in the career field, the duties of transporters, and CONUS and overseas locations that OMC personnel should visit to interview transporters in constructing the survey instrument, a USAF job inventory.

Since January, occupational analysts from OMC have interviewed approximately 200 transporters in constructing the job inventory. Following validation by OMC and transportation personnel, this job inventory will be administered to all Transportation Officers and equivalent grade civilians to assess the tasks members perform in their current jobs. The results will be provided to trainers and career field monitors in the summer of 1982.

Air Force Transporters will have the opportunity this fall to influence future transportation classifications, training, and utilization decisions by completing job inventories. Thoughtful, and timely accurate completion of the inventory by all transporters will help insure that properly trained and utilized transporters are available to meet the challenges of the 1980's.

(USAF Occupational Measurement Center/OMYA, Captain Griffith and Mr. Ditullio, Autovon 487-6623)

Network Analysis: A Vital Tool for Integrated Logistics Support Management

Albert L. Clark
Logistics Management Specialist
Acquisition Logistics Procedures
Air Force Acquisition Logistics Division
Wright-Patterson AFB, Ohio 45433

Abstract

The application of Integrated Logistics Support (ILS) in the system acquisition process requires a unified approach to the management and technical activities necessary to cause support considerations to influence both requirements and design, define support requirements which are optimally related to the design and to each other, and acquire the required support. The implementation of network analysis can be a valuable tool in providing this unified approach, as well as in scoping the multitude of activities associated with the ILS concept. Areas of discussions in this paper include the following:

a. Inherent problems in the management of an ILS program.
b. Use of network analysis as an effective management tool.
c. Creation of a computer software package to simplify networking and integrate it as the driver of a management information system.
d. Development of model networks for ILS activities.
e. Benefits derived from actual application of a model ILS network.

Introduction to ILS Management

When aerospace or other systems and equipment are retained in active use for extended periods of time, the support costs far exceed the original purchase prices. In order to lower the total life cycle cost, in particular the support costs, and to increase supportability, the USAF adopted the Integrated Logistics Support (ILS) concept in 1964. This concept calls for identification of the support cost drivers early in the acquisition of a new system. By identifying these support costs early, the system requirements and the support requirements can be traded off with each other to achieve the best overall system and support package to meet mission requirements for the lowest total costs over the life of the system. The specific ILS elements injected into the system's acquisition process are:

a. Reliability and Maintainability
b. Maintenance Planning
c. Support Equipment
d. Supply Support
e. Packaging, Handling, and Transportation
f. Technical Data
g. Facilities
h. Manpower Requirements and Personnel
i. Training and Training Support
j. Logistics Support Resource Funds
k. Logistics Support Management Information
l. Computer Resources Support
m. Energy Management
n. Survivability
o. ILS Test and Evaluation

Early efforts at integrating these logistics elements into the systems acquisition process were exemplified in DOD Directive 4100.35G, *Integrated Logistics Support Planning Guide for DOD Systems and Equipment*, 15 Oct 68, which had a basic flow chart of logistics elements within an acquisition process.

USAF Organizational Changes

This new emphasis on acquisition logistics recognized the need for more participation by Air Force Logistics Command (AFLC) within the acquisition process. In order to increase the level of logistics participation in acquisition programs, a new Deputy Program Manager for Logistics (DPML) position was created in 1968. Despite the increased emphasis on logistics, the logistics portion of systems acquisitions was still lagging behind, resulting in marginally supportable systems, while support costs of these new systems were still climbing. In 1976 a new organization was formed to work this integration problem, the Air Force Acquisition Logistics Division (AFALD).

Development of Improved ILS Management Tools

The formation of AFALD assembled many specialists dedicated to improving acquisition logistics. This, in turn, resulted in the development of many new ILS management tools to cause the integration of logistics into systems acquisition.

Logistics Support Analysis (LSA) is a management technique required on all new acquisition programs. The purpose of this tool is to integrate logistics and system development through an iterative process of identification and trade-offs of support requirements against each other and the system.

Life Cycle Costing (LCC) is an analytical management technique required on all new acquisition programs. Several computer life cycle cost models were created to project system life cycle costs resulting from modifications, redesign, alternative support scenarios, support equipment, etc.

Repair Level Analysis (RLA) is a quantitative model required on all new acquisition programs to trade-off the various levels of maintenance for the lowest costs. Costs of spares, support equipment, man-hours, transportation, etc., are computed for the various levels of maintenance in order to impact the design of the system and maintenance requirements. The basic levels computed are depot, intermediate, organizational, and discard.

The emphasis on both ILS and management techniques is increased and included, at least in part, in DODD 5000.1, *Major Systems Acquisition*, 19 Mar 80; DODI 5000.2, *Major Systems Acquisition Process*, 19 Mar 80; DODD 5000.39, *Acquisition and Management of Integrated Logistics Support for Systems and Equipment*, 17 Jan 80; and more specifically in AFR 800-8, *Integrated Logistics Support (ILS) Program*, 7 Feb 1980. The regulatory guidance is not complete but is becoming stronger as the importance of acquisition logistics grows.

An Integrated Logistics Support Plan (ILSP) is required on all new acquisition programs. This plan explains the logistics actions to be incorporated in the system acquisition in order to develop a supportable system. However, current ILSPs do not explain how the different events and activities interrelate or how they may be dependent upon another event or activity.

The need to interrelate these events and activities has resulted in many attempts at developing some form of networking tool for this purpose. None have been completely successful. The basic flow chart in DODD 4100.35G provided some understanding of the concept of ILS but did not actually show the integration of the ILS elements. Milestone charts have been required to show the relative timing of events and to show the progress of the logistics efforts, but, since there were no dependencies considered, logistics was still a disjointed effort with frequent unforeseen slippages.

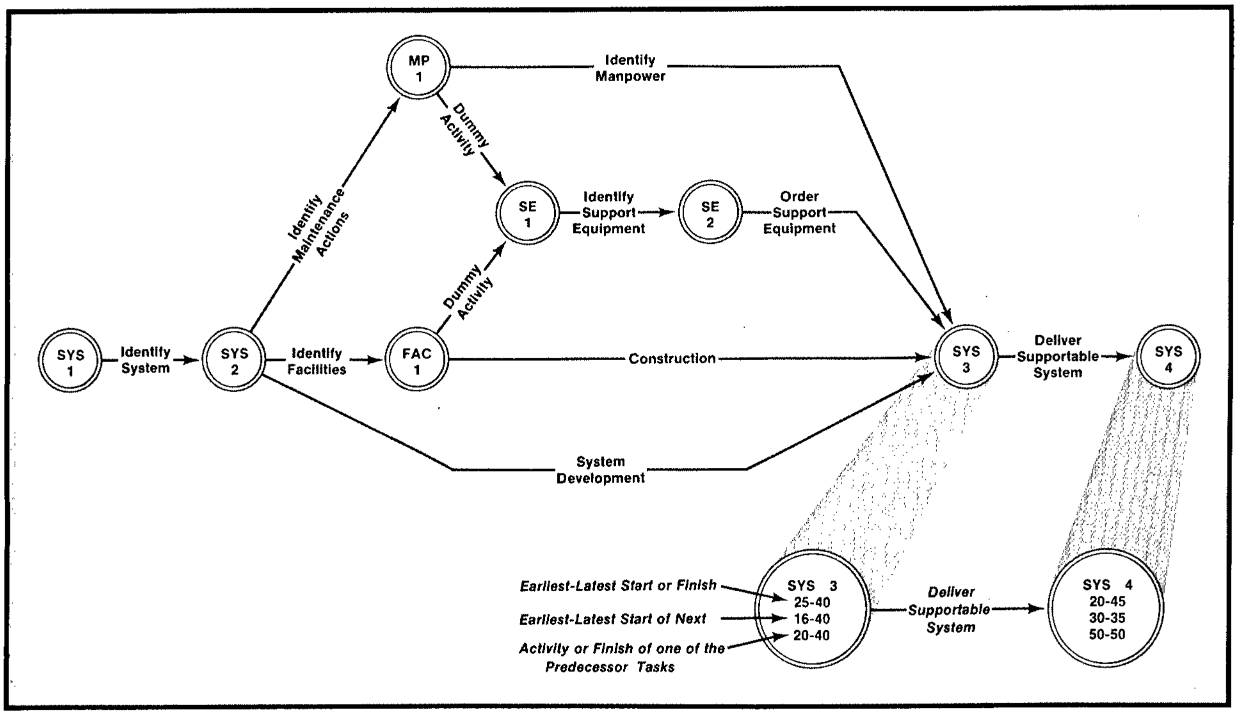


Figure 1. Simple PERT Network

Network Analysis

In trying to solve many of the problems in ILS it became obvious that some method had to be found to show the interdependencies and relationships of the ILS elements and the system development process. Many management systems were studied. The management method selected was networking and it is now required on all acquisition programs.

The most widely known technique of networking, especially in managing development activities, is the Program Evaluation and Review Technique (PERT). Standard PERT, however, was found to have several weaknesses as applied to the objective of integrating ILS elements with existing system development activities.

A typical PERT diagram is satisfactory for a simple network but rapidly becomes very complex when it approaches 100 or more activities. Figure 1 is an example of a simple PERT network. Whereas the nodes used in standard PERT may represent events, they frequently only identify the start and finish of activities. Quite often confusion can occur from the fact that more than one activity may end and start at a node. As a result, this form of networking does not easily lead itself to computer processing or properly displaying a graphic project plan. Nodes can be drawn to a limited size and as more information is added, the nodes become saturated and confusing as to what they represent (see detailed nodes in Figure 1). In such cases dummy nodes must be loaded, which

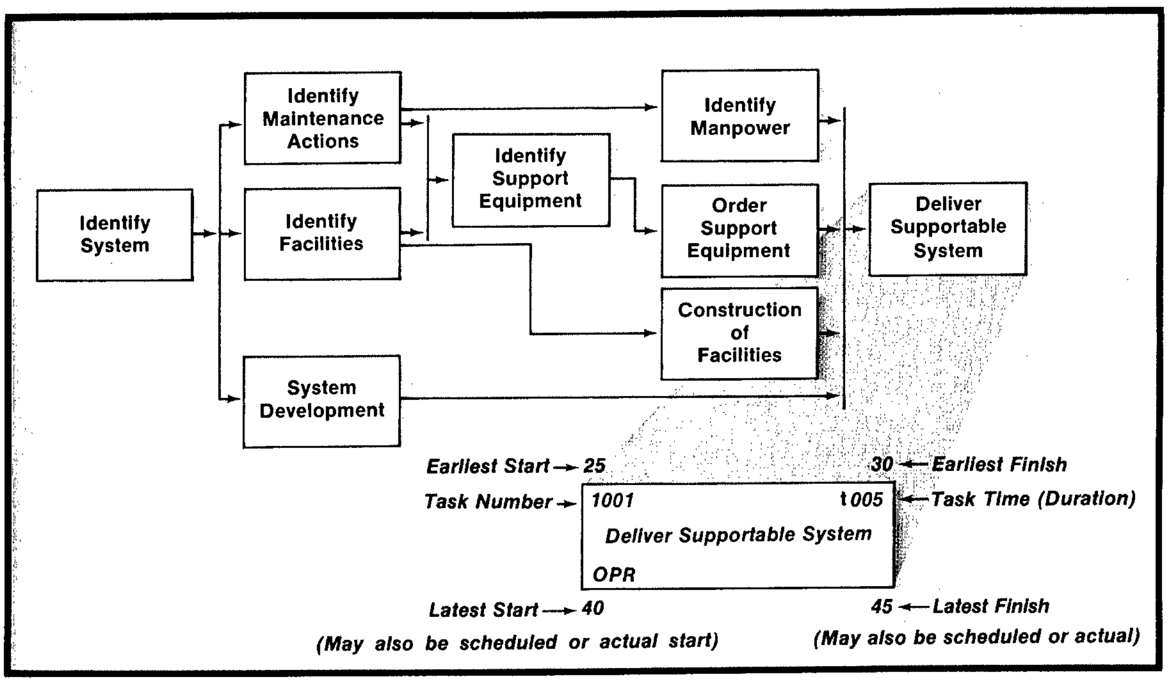


Figure 2. Adopted Networking Method

results in the loss of information clarity, or activity schedules, slack times, etc., must be obtained from all other listings to eliminate the display of all information on the drawing.

In contrast, the networking technique adopted overcomes these drawbacks. Its application steps are: identify the activities and events required to do the project; line them up horizontally by predecessor and successor relationships, assign a time to accomplish each and then compute the critical path and slack times. The system recognizes both activities and events and combines them into an element called a "task." An event becomes a zero time task and is considered the same as an activity. All tasks should have a meaning in networking. In the adopted system, the start and finish times are associated directly with a task, thereby eliminating a separate network entry for start and finish. A simple graphic network like that used by AFALD is shown in Figure 2 with one task shown in detail.

Network Analysis by Computer

Any networking technique becomes very time consuming when manually drawn. Networking should be an initial plan updated continuously to show changes as well as progress and eventually become an audit trial for the project. An acquisition program will have hundreds of events and thousands of dependencies. Manually redrawing the networks and resultant milestone charts is simply not practical even if sufficient manpower was available. This additional need to computerize networking launched an effort to find government or commercial software that could take a simple set of data inputs and produce network graphics, milestone charts, listings, etc. The results of this search were not encouraging. Milestone charts or schedules not resulting from network analysis have limited value and there are very few computer software systems that produce schedules in the form of milestone charts from a network. The few systems found that performed all these functions required either excessive input data, excessive manual computations, or were too complicated for a non-computer operator to master. Most of our program offices have no computer experts. A few systems were found that could handle simple networks and didn't require a computer expert but the software could not handle more complicated projects due to limitations on the number of interdependencies. Many of the systems were not realtime where you can modify the data and see the results immediately. Some systems required turn-around times of from 3 weeks to 3 months between input and output due to batch card processing versus realtime input/output.

Since an already available networking software package could not be found that satisfied our needs, the reasonable alternative was to tap AFALD resources to create an organic software capability. Within four months, AFALD had a useable software package that met all of the original criteria. Development efforts are continuing to enhance this software in an attempt to tie networking into a complete planning, scheduling, and management information system. The next evolution of this effort is the creation of software such that a significant change anywhere in a data file will automatically update any related information elsewhere in the acquisition program's management information system and/or produce exception reports.

This software was designed to satisfy our requirements that could not be satisfied by other available computer systems. A significant improvement is that it displays the adopted form of network graphics in realtime where a user may input a change to the data on a common remote terminal and have the outputs, including graphic drawings, on that same terminal. A big advantage to this is that a manager may game the project by inputting a proposed change, see the projected impacts, and try new proposals having more or less impact until a decision has been made as to what downstream result is most acceptable. Any system requiring excessive processing time would not be useable in a gaming mode. When the manager is not concerned with a realtime product, the manager may also select products to be output on either a batch printer or a plotter which will produce a drawing of the quality of a graphics department.

The second significant improvement is that the software operates interactively with the user. All input and question routines were kept extremely simple utilizing conversational English with edits for almost any conceivable error. Even though the composition of the network requires top management effort, a nontechnical individual can easily operate the software to input data and generate reports. The quantity of input data is being deliberately kept to the bare minimum in order to make network analysis simple and easy to use. The computer then takes this minimum input to compute a maximum output. Even the network diagram task locations are computed.

This software has made network analysis an easy planning tool to use and has made it attractive not only to acquisition management but to managers of other types of projects.

Model Networks

Due to the ease of modifying an existing network, the software has made possible the creation of a new management tool - model networks. Model networks were created for each of the ILS elements to show the step-by-step development of each and the dependencies of that ILS element. Model ILS networks have been created for each phase of an acquisition program. The various acquisition programs then tailor copies of the model networks to build unique networks for each acquisition.

The procedures used require the program office to get computer access and file space, copy the model networks onto their file space, then tailor the models until the network represents their acquisition program versus the model.

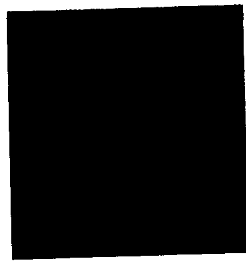
The networks are then subtiered to show levels of management attention. For example, a top level network will show only those tasks that top management wants to monitor such as a single task that reflects preliminary system design taking 50 weeks. The next lower level network shows the 20-100 major tasks that must be accomplished during preliminary design. The next lower network may show the subtasks required to do one of the major tasks required during preliminary design. One of these lower level networks may show the detailed steps required to accomplish one of the ILS elements during preliminary design. Lower level networks will be constructed to show the lowest level task any level of management may want to monitor.

The tailoring of networks involves adding/deleting tasks or events, changing times, descriptions, responsible office symbols, scheduled (versus computed) start and completion dates, and adding/changing/deleting dependency relationships. The manager may then have the remote terminal print out the graphic networks, milestone charts, listings, etc., in various formats and data slices by event, time, responsible offices, etc. Each of these reports will show earliest start and finish times, latest start and finish times, positive slack (or negative slack when the manager has input an unacceptable scheduled versus a computer generated start or completion time), critical path, and program times/dates. The manager then makes further changes until a workable plan has been configured.

Model networks that are easily modified by using the developed software create several advantages. Their use cuts down on the planning time required because each program does not have to create a network from scratch. They improve planning because the model networks already include known dependencies between tasks that individual managers might not recognize until too late in the program. Since most of the tasks are already loaded on the data file it is quicker to tailor than to have to load the complete file. The various networks that different programs have used become a lessons learned file that can be used for updating the models or providing a model for particular applications. Model networks also serve as an advanced style of checklist for managers to use. The important thing that must be remembered, however, is that a model serves only as a departure point that reflects the usual tasks and events with standard dependency relationships.

Continued on page 29

Chinese Logistics Doctrine - A Reflection of National Imperatives



Lloyd K. Mosemann II
Deputy Assistant Secretary
(Logistics)
Department of the Air Force
Washington DC 20330

In December 1980 an American defense logistics delegation spent two weeks visiting military installations in the People's Republic of China as part of a beginning military dialogue between our two nations. The Chinese were anxious for the Americans to review and comment upon their capabilities and to provide specific recommendations for modernization. As this dialogue increases, a thorough understanding of the fundamental cultural and historical basis for current Chinese military policies, structure, and objectives for the future is essential on our part if the relation is to have positive results. To help increase this understanding within the professional logistics community in the Air Force, some observations resulting from the trip are described in this article.

Perceptive readers will immediately notice several basic differences between American and Chinese military organization and leadership and management emphasis. It is important to remember that, for the most part, "different" means neither better nor worse. In general, the Chinese are realistically using available national resources. In some areas, they are clearly working for change. In other areas that might also appear to require change, broad national priorities may rightfully dictate a continuation of the status quo well into the future.

In reflecting upon this visit, I have been most struck by the fact that military logistics doctrine really does mirror national priorities and perceptions. In subsequently considering our own USAF approach to logistics doctrine, it has become easier to visualize why we are what we are, and to project more realistically changes in logistics doctrine which may be meaningful for the future. With these general thoughts in mind, let me share with you some impressions from the Chinese visit; perhaps you will also begin to perceive cultural extrapolations which affect our Air Force logistics destiny.

Concept of People's War

Fundamental to Chinese logistics doctrine is the remembrance that China's strength is people and land mass. Past military successes (including the "Long March" and the return therefrom) have depended on staying power, i.e., luring the enemy deep and outlasting him. This requires logistics support of not only a large army, but of virtually the entire military age population which constitutes the militia, all of which are integrated into a single integrated army in a major mobilization.

Today, the effects of this past are evident in three profound ways. First, the PLA (People's Liberation Army) is essentially the Department of Defense. The Navy and Air Force are sub-elements roughly comparable to the Army Arms of armor and artillery. The General Logistics Department (GLD) of the Army is, therefore, the pervasive mother of all logistics doctrine.

Secondly, the basic organizational structure is decentralized, with the Military Region as the primary element. At all levels the Air Force is essentially subordinate to the PLA. There are over 500 different supply depots, some of which are GLD level reserve depots, some are Military Region or Military Service Depots, and some are at sub-department and provincial levels.

Finally, the prerequisite for command is experience in the 1940s PLA. For example, most senior Naval and Air Force officers, in addition to 25-30 years experience with Navy or Air Force, also have 10-20 years of prior experience in the Army. Hence, the leadership at all levels are in their 60s, or older, and most other officers are in their 30s. Few in between or in their 20s were encountered. This latter fact is most likely attributable to the Cultural Revolution, during which military educational activities largely ceased.

劳埃德·摩斯曼先生

Concepts of Communist Society

Virtually the entire Chinese population is organized into communes or collectives (although not necessarily identified as such). Economics are oriented to assuring that all have a job and a "good living." Directors of large enterprises, whether a military factory, fuel depot, engineering school, or agricultural commune, must give attention to schools, recreational facilities and production of both vegetables and livestock. Hence, maximum productivity and cost effectiveness in any single, narrowly defined area will be difficult for the immediate future. On the other hand, however, the Party's slogan that "One (child) is enough" seems quite effective and should ultimately result in a precipitious population decline and the concommitant need for increased mechanization.

The Chinese revolutionary past, and their resultant perception of the Russian threat, seem to foster self-sufficiency, compartmental thinking and vertical specialization.

The PLA Ordnance, Quartermaster, Transportation, etc., as well as Navy and Air Force, each have vertical systems issuing separate supply, maintenance and transportation policies. Also, each repair factory is manufacturing parts necessary for repair. There is no program to have the factories manufacture more of the same items for the supply system or for each other. There is not a single unified cataloging program. This vertical delineation exists at the national level, at military region level, as well as at the sub-department, provincial, and garrison levels. It is true of factories even with the same commodity. It is also true at the worker level. A worker may perform exactly the same bench function virtually his entire working life. There is very little geographical mobility among officers - the military, even in the active force, are, for the most part "civilians in uniform."

Fact of Technological Retardation

The military leadership at all levels recognizes and acknowledges that China is a "developing nation." With respect to development priorities, military modernization is 4th after agriculture, industry and technology. Hence, emphasis has been mainly on sustaining existing equipment rather than buying new equipment. Aside from the fact that aircraft technology is largely of 1950s vintage, the most obvious example is that 1942 Dodge 4 x 2 four ton trucks, without front wheel drive, were still being produced, new, as recently as 1975.

Technology is essentially being installed in depots and factories on a self-help basis. In the industrial plants, there is little or no safety equipment; viz, no goggles, no safety shoes, no hard hats (not even in the shipyard dry docks), no guards on lathes and cutting machines.

Little ADP is being used in management applications. Telecommunications consist mainly of telephone and telegraph. There is little organic military airlift capability. Notwithstanding these facts, there is strong evidence that the PLA does not suffer from shortages of spare parts, ammo, food or POL. There is little evidence of the need to expedite to cover shortages. Rather, the evidence is that multi-echelons have in-depth stocks in all these areas.

The Air Force Engineering College, which apparently is the most senior technological study institution available to the Air Force, consists essentially of a college level curriculum into which maintenance and production quality assurance technical training has been incorporated. Advanced math and computer related analytical techniques are essentially unknown as management tools.

"Bottom Line"

Clearly, the Chinese must decide, before any other country can provide management and technical assistance, where they want to go and how fast they want to get there. The solution must be a Chinese solution and will reflect the unique political, cultural and economic accouterments of China.

My concern, on reflection, is that we may not fully understand within the U.S. the implications of our unique political, cultural and economic forces, particularly as these have evolved not only historically, but in more recent times. There is, as Alvin Toffler indicated in his recent book, a Third Wave coming—evidence is all around us. The implications for shaping our USAF logistics structure must be identified and made apparent so that we, too, can decide where we want to go and how fast we want to get there.

Impact of the Comprehensive Engine Management System on Air Force Aircraft Maintenance Organizations

Captain Daniel J. Somers
CEMS Project Office
Maintenance Systems Development Branch
Air Force Data Systems Design Center
Gunter AFS, Alabama 36114

Abstract

As the Air Force presses for higher performance aircraft jet engines, and as their acquisition and replacement costs skyrocket, management techniques must adapt to obtain maximum benefit and life from each engine. Small changes in the performance of new high technology engines may signal significant component or operational problems. Unfortunately, there is a considerable gap between the capabilities of the on-board engine monitoring systems and the abilities of manual base level data processing systems to assimilate the volumes of gathered data and produce meaningful engine management reports. To breech this gap, the Comprehensive Engine Management System (CEMS) was formulated. Upon implementation in August 1982, CEMS will permit the tracking of engine components on selected engines by up to 19 different methods, thus providing a means of knowing the current status of a given component. This will allow the actual condition of the component to "drive" its replacement versus some arbitrary number of hours since overhaul, etc., as used in the past. The organizational impact of CEMS will vary across the Air Force and will depend primarily on the existing engine tracking methods it replaces and on major command decisions.

Introduction

Engines have now replaced electronics as the costliest entity in the life cycle of new aircraft weapon systems. To cope with the quantum cost jumps high performance engines now incur, as well as holding down the cost of current inventories, entirely new Air Force management procedures and organizational structures have begun evolving. Looming large in the future of Air Force maintenance is the Comprehensive Engine Management Systems (CEMS).

This article takes a brief look at the factors that have necessitated development of CEMS, its primary purpose and objectives, the way it will carry out current on-condition maintenance policies, and the resulting impact on aircraft engine management procedures and organizations. Basic equipment, cost and anticipated benefits associated with CEMS will be discussed.

Background

In general, the production of higher performance aircraft jet engines through modern technology has had revolutionary impacts on engine management and information systems. In the past, engines were heavy and rugged enough that rough approximations about their ability to perform the next missions were all that was necessary. However, today's propulsion troubleshooting has been forced to recognize that even small changes in the engine's performance over a period of operation indicate impending component failure or degraded operation. The full realization of aircraft engine logistics efficiency has been hampered by the gap between this high degree of intolerance of new engines to small performance variations and the relative inability of engine sensing systems to track the voluminous data necessary in gauging an engine's "health."

Within the Air Force, several specific developments during the past decade provided an undeniable imperative to developing sensing and management systems more finely tuned to modern engine technology. In December 1973, an Air Force Inspector General report on engine management indicated that the current engine data system was not responsive to major command needs. [2:2-1] The advent of a new propulsion system on the F-15 and A-10 generated additional data requirements such as engine health monitoring diagnostics and component tracking of time change and low cycle fatigue items. Data systems requirements also needed to consider the propulsion system on the F-16 and the work by the Air Force Data Systems Design Center (AFDSDC) on the Maintenance Management Information and Control System (MMICS) at the base level. Collectively these events precipitated the need for a combined effort by all levels to develop a total systems approach to engine management. Thus the Comprehensive Engine Management System (CEMS) was conceived.

Purpose

CEMS is being developed to eliminate known problems, enhance overall engine management, and satisfy the engine management needs of the Air Force Logistics Command, major commands and operating bases. As now envisioned, CEMS will document the functions accomplishing engine management and associated information requirements. These functional areas will include distribution management, configuration management, inventory control, supply support, management analysis, and maintenance management. When CEMS is implemented in August 1982, emphasis will be on data use, timeliness, and information access capability.

Objectives

The primary objectives of CEMS are:

(1) Maintain removal and installation actions of engines, modules, or components and report these actions for the F100, TF34, TF41, TF30, TF33, J60, and J85 engines [2:5].

(2) Update and create records of time accrued on engines, modules or components in terms of tracking cycles, total operating time, total flying time and/or time-at-temperature for the engines listed above.

(3) Maintain time change standards and notify Plans and Scheduling when engines, modules or components have expended their time remaining or are projected to exceed their limits.

(4) Automatic Engine Management Reporting from base level to MAJCOM and AFLC [5:2-1] to:

(A) Eliminate current keypunch requirements.

(B) Reduce errors through editing at time of input.

(C) Automatically provide engine status reports via AUTODIN to the Central Data Bank at Oklahoma City Air Logistics Center.

(5) Automate Accountable Engine Shipping Devices Management/Reporting [5:2-1] to:

(A) Maintain cumulative total of shipping devices on-hand.

(B) Maintain total of serviceable shipping devices.

(C) Reduce or eliminate most of the command directed shipping device reports.

(6) Completely mechanize the base engine manager's records/operations, i.e., sequence control, transaction register, engine intransit days (exception reports), etc.

On-Condition Maintenance

CEMS is the vehicle for accomplishing the Office of the Secretary of Defense directed on-condition maintenance (OCM) for selected high technology and current inventory engines. On-condition maintenance allows the condition of the equipment to dictate the need for maintenance or the extent of the repair/overhaul required. OCM supplements the existing interval driven maintenance, total rebuild engine overhaul policy and more closely aligns the Air Force with commercial profit-driven policies.

At unit level, this means that whole engines will no longer be sent to overhaul based on Maximum Operating Time of the engine, nor will the engines be pulled for inspection based on time-since-overhaul. Instead, components and modules of engines are sent to depot for overhaul based on their operating times. Likewise, engine components and modules are inspected at the unit level based on operating times since new or overhaul. A further complication of this process is the fact that engines under OCM, particularly engines using newer technology (e.g. TF34, F100) and problem engines, have parts that are each "tracked" for removal for overhaul or inspection using different usage factors. For example, certain parts on an engine may be tracked for removal using Engine Operating Time. Other parts may be tracked using cycles (throttle advancements) or sorties. Furthermore, the potential exists for a part to be "multiple-tracked" by two or more tracking methods, with the tracking method that first exceeds the preselected Maximum Operating Time or Time-Since-Overhaul being what "drives" that component out of an engine for inspection or overhaul. The volume of engine-related information to be monitored and used at the base level is multiplying. Under OCM, instead of tracking only one hundred or, at the most, two hundred engines, base level engine personnel will be required to individually track thousands and even tens of thousands of parts. Instead of one method of tracking usage (flying times), several tracking methods must be monitored for a particular engine type.

Accurately maintaining usage information to identify modules and components needing inspection and time changes, and reporting the current status and usage of engines, modules, and components to Air Force Logistics Command would be an impossible task if done manually at the unit level. The result would be inaccurate and lost information, with related negative impacts on the usage life of parts and engines and most importantly, on safety of flight.

Two new Air Force engines have been brought into the inventory under OCM—the F100 engine (used on the F-15 and F-16) and the TF34 (used on the A-10). The need to automatically track the parts on these engines forced development and implementation of base level and central data base tracking systems (one at Oklahoma City Air Logistics Center and one at the General Electric plant at Lynn, Massachusetts). However, these systems are one-time programming efforts designed specifically to support these engines on an interim basis until CEMS is implemented. In addition, these systems do not meet all the requirements of CEMS, only those minimum capabilities absolutely required to keep up with engine and parts usage. Finally, a number of older engines (specifically the TF33 and J85 engines) have also gone under on-condition maintenance without supporting data systems. Manually tracking these engines has become very difficult at both the base and depot level.

A slightly detailed description of the F100PW100 tracking system illustrates both the current tracking technique and the problem it creates: the data deluge of an intricate bookkeeping system. The on-board systems consist of sensors that detect certain engine temperatures and speeds. These signals are transmitted to the Events History Recorder (EHR) (see Figure 1) installed on each engine to record the operating times, times at various temperatures, and idle-to-maximum cycles accumulated for a particular engine run-up or flight. The EHR is similar to a household water meter in that the signals increment rotary dials that must be read after each flight. These data are recorded on a form by the crew chief (with some difficulty because the EHR is not easily accessible). The form also includes a pilot's manual input for the number of times he accelerated the engine RPM from zero to approximately 87 percent. The completed form is routed to the engine shop documentation section where the data is entered into MMICS.

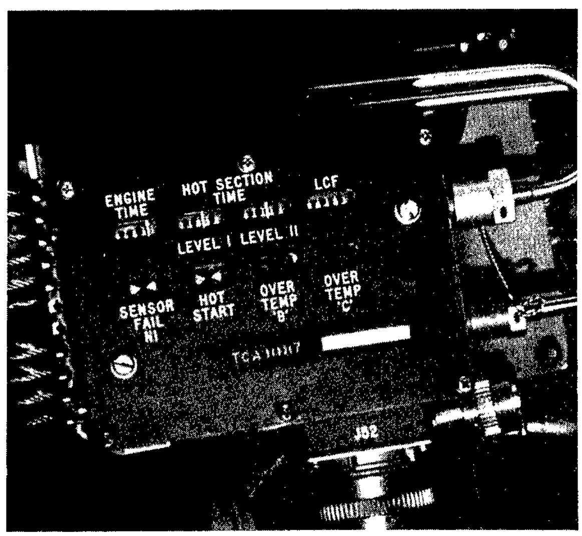


Figure 1. Events History Recorder on F100 Engine

MMICS represents a big part of the off-board tracking system. The data enters the base level computer through a video display terminal located in the engine shop documentation section and passes several edits to ensure the EHR is working and the numbers the crew chief recorded on the form were probably accurate readings.

Organizational Structure Impact

The impact CEMS will have on maintenance and data processing organizations Air Force-wide varies from unit to unit, base to base, and command to command. The only thing fairly certain at this point, since CEMS is still in its development stage, is that the Data Processing Centers should not feel much of an impact. CEMS will primarily enhance the present MMICS since it will, when implemented, simply become another input of MMICS and will not be treated any differently by the Data Processing Center [5:2-5]. The major impact will occur in organizations and commands not currently possessing any automated aircraft engine monitoring systems, and particularly in those units without even a manual engine monitoring system such as the one SAC currently has. Currently only a few commands, such as MAC on its C-5A and TAC on its F-15, F-16 and TF-34 have a truly automated engine tracking system. TAC's present system dubbed "little CEMS" is a TAC in-house effort to provide the essential organizational support required by the F-15 and F-16.

"Little CEMS" (Combined Engine Management System) was a precursor of CEMS and was actually an organizational restructuring to bring various talents (AFSCs) into one office under one supervisor for the sole purpose of better managing the F-15/16 and A-10 aircraft engines[1]. TAC collocated the Base Engine Manager (BEM), the engine shop scheduler, parts tracking personnel, TCTO monitor, etc. TAC has found this pooling of talent to be tremendously successful, enabling the command to manage the enormous task of monitoring the F-100 engine used in the F-15/16. For example, the F100 engine consists of 7 modules made up of 92 components (fuel pumps, turbine blades, etc.) which are currently tracked by one of two methods—engine operating time or engine cycles. Under CEMS, this tracking capability will increase to as many as 19 different tracking methods per component. Since a typical F-15 base may have more than 200 engines, each consisting of 7 modules, this equates to over 1400 modules to be monitored. These 200 or more engines with 92 components each equal at least 18,400 components on just the F-100 for one Air Force unit to track. If these 18,400 components were tracked just two different ways each, such as time at temperature and hours of operation, there would be 36,800 items to monitor. Many components though, as previously stated, may eventually be tracked up to 19 different ways.

Currently, F-15 wings track up to 18,000 parts. Without the present limited parts tracking automation provided by MMICS and the reorganization under "little CEMS", daily tracking of these parts would require up to 35 individuals working full-time. With "little CEMS" and the current MMICS, TAC is able to perform this function with approximately six people per wing [1]. The significance of CEMS, though, is that when fully implemented in FY 82, it will permit these same six people to track these same 18,000 parts, not just 4 or 5 ways, but up to 19 different ways each [4: A7-1 A7-4].

CEMS will be one of the few Air Force automation programs that has not required a trade of "bodies" (manpower slots) for computers. Actually the prevalent view is that manpower is currently stretched so thin that if "bodies" were sacrificed, units could not perform this tracking—even with CEMS; therefore, no loss of personnel is currently anticipated. For base level units currently utilizing the MMICS Engine Tracking Subsystem, the impact of CEMS will be relatively minor and oriented towards the procedural differences between the current, specialized engine tracking approach (little CEMS) and a general engine tracking system under CEMS.

Units belonging to commands not under on-condition maintenance or with no tracked engines may have significant organization changes unique to their requirements and the characteristics of the engines to be tracked. CEMS will not direct a specific organizational structure. However, the collocation of the BEM and the engine tracking personnel within the engine shop appears to be the preferred direction of movement for the majority of commands.

The BEM may not only be relocated, but will have his job restructured to incorporate an on-line engine management system (5:2-5). This will eliminate the keypunching of data constant in the data base. CEMS will enable the BEM, through one input, to create automatically reports that previously required the keypunching of as many as nine separate cards. The BEM will also be provided a video display terminal input of MMICS transactions specifically tailored to meet his management requirements. This system will also eliminate many common errors by performing edits at the time of data input. Though this change from a manual to an automated system will require some adjustment in task orientation by the BEM, most BEM have enthusiastically endorsed it. CEMS will also automatically transmit reports to the CEMS Central Data Bank (CDB) for use in the procurement of spare parts and engines. In addition, CEMS will provide a method for managing Engine Shipping Devices (e.g. engine trailers, containers, etc.) which have traditionally been a difficult area to manage.

Equipment

Base level CEMS will be processed as part of MMICS. MMICS is processed on the Burroughs 3500/4700 computers (until replacement computers are procured by the Phase IV Program). As a part of MMICS, the base level CEMS will be on-line and transaction oriented. The system will utilize existing printer and tape drives and additional disk storage (an estimated maximum average 200,000 bytes per tracked F100 engine with 100 tracked parts) [4:4-1]. Units will be provided video display terminals with cassette/diskette and printer on a proportional basis based on the number of aircraft assigned.

Cost

What will CEMS cost? CEMS is not cheap by any means, but in comparison with the alternatives—loss of aircraft, crews, or disintegration of entire engines—it may be a bargain. With high technology engines, such as the F100, costing between 1.75 and 2 million dollars a copy and increasing in acquisition price yearly, CEMS may rapidly pay for itself. For example, the author had responsibility in 1977 for a very crude, manual tracking system for engines on the KC-135A. Though this system monitored only fuel flow, EPR, exhaust gas temperature combined with SOAP (Spectrographic Oil Analysis Program) and was in a very small wing (less than 20 aircraft) it had a cost avoidance of $822,000 the highest in SAC in approximately eight months. It tremendously improved aircraft reliability and almost totally eliminated in-flight engine shutdowns due to "shell out" (engine disintegration).

Base level CEMS will require the expenditure of 60 manyears and $2,781,000 for development with an additional 1,126 manyears and $27,252,000 required for operational expenditures. This will be a total expenditure for base level CEMS of 1,186 manyears and $30,033,000 [2:5-1] during the ten year life span of FY 79 through FY 88.

The modification of the CDB at Oklahoma City ALC will require the expenditure of 207 manyears and $10,678,000 for development with an additional 1,336 manyears and $35,860,000 required for operational expenditures. This will be a total expenditure for the CDB of 1,543 manyears and $45,598,000 [2:5-1].

Therefore, the total estimated CEMS base level/CDB expenditure is 267 manyears and $13,459,200 for development with an additional 2,460, manyears and $63,112,000 for operational expenditures. This will be a grand total of 2,727 manyears and $76,571,000 [2:5-1].

Immediate dollar savings will result when interim data contracts are cancelled amounting to $6,196,000 [2:5-1]. The resulting engine reliability and extended engine life savings are in excess of the $76.5 million cost of CEMS, but no exact figures have been published. However, considering that the Air Force now has 9.4 billion dollars invested in installed and spare aircraft associated engines, and this is based on their acquisition cost not their current replacement cost, the savings potential becomes much more apparent. [6]

Conclusion

As advances in high technology engines continue, and their procurement costs escalate, automated monitoring systems such as CEMS are being sought to insure maximum engine performance and life expectancy. As CEMS evolved over the past few years it became increasingly apparent that Air Force maintenance organizational sructures would have to change. Anticipating the delivery of the F-15/16 and A-10, TAC implemented "little CEMS". "Little CEMS" reshaped TAC's engine management organization and allowed it to encompass the huge influx of components requiring tracking. Though the cost of CEMS is high, its cost is offset by the long-term benefit of extending the life expectancy of these new high technology engines.

The effect of CEMS on the Base Engine Manager will be a significant restructuring of his job. Though the introduction of an on-line system will increase the accuracy of his reports by performing edits at the time of input, much human adaption will be required for adjustment.

Overall, CEMS is possibly the only means for the Air Force to be certain of the condition of its new high peformance engines. This knowledge may well mean the difference between victory and defeat in the next conflict. As these engines push the boundaries of known technology, they become ever more sensitive, and less tolerant of performance/environmental variables.

References

[1] Allen, Major Roger. 3 Nov 1980 Interview. (Former) HQ TAC/LGMQP, Chief Automation Division.

[2] CEMS Data Project Plan (DPP-HAF-D-76-001(2)), 21 July 1980. CEMS Development Project Office, OC-ALC, Oklahoma.

[3] CEMS Functional Description (FD-D-18036), 21 July 80. CEMS Development Project Office, OC-ALC, Oklahoma.

[4] CEMS Increment I/II Functional Description (FD-D-18036-I/II), (Base Level), 30 Oct 80. AFDSDC/LGMDI, Gunter AFS, Alabama.

[5] CEMS Increment III Functional Description (FDOD-18036-III), (Base Level), 30 Oct 80. AFDSDC/LGMDI, Gunter AFS, Alabama.

[6] *Propulsion Unit Inventory-Monthly Summary* (D024, BDT 1-D, Part IV), 30 Jun 1980. OC-ALC/ACDTP.

Most Significant Article Award

The Editorial Advisory Board has selected "Munitions Logistics" by Colonel Johnny E. Cormier, USAF, as the most significant article in the Spring 1981 issue of the *Air Force Journal of Logistics*.

CURRENT RESEARCH

Air University Logistics Research in the PME Classes of 1980-81

The logistics related research papers and projects completed by the students of Air War College and Air Command and Staff College during the 1980-81 academic year are identified below.

The Society of Logistics Engineers' Logistics Award was presented in the Air War College to Lt Col Robert F. Swartz for his paper, "A Comparison of Selected Specialized Logistics Support Systems," and in Air Command and Staff College to Major Harold Carter for his paper on "A Preliminary Investigation of Life Cycle Costs of a Digital Avionics Processor Using Very High Speed Integrated Circuits."

Air War College

"A Comparison of Selected Specialized Logistics Support Systems" - Lt Col Robert F. Swartz

"US Military Security Assistance: Some Economic Considerations and Policy Implications" - Colonels Harry W. Glaze and George L. Getchell and Lt Col Martin W. Nakunz

Air Command and Staff College

"Application of Source Data Automation Techniques to Base Supply Bench Stocks - Benefits to be Gained?" - Major John B. Alford

TACS Maintenance Workcenter Supervisor Handbook - Majors William A. Barker and George C. Bauer III

"Career Enhancement Training for 431XX APG Maintenance Technicians" - Majors Ronald G. Brohammer and Cullen L. G. Davidson

A Handbook for Air Force Modification Management - Majors Thomas H. Burleson, Jr., Gerry R. Daugherty, G. Richard Fraas and Peter E. Ramm

"A Preliminary Investigation of the Life Cycle Costs of a Digital Avionics Processor using Very High Speed Integrated Circuits" - Major Harold W. Carter

"BOMB-MAN-X" (Bomb Management Exercise) - Major Gary A. Chabot

"Valid Charges for Administering the Foreign Military Sales Program - A New Perspective" - Major John Paul Clarke

"NATO Logistics Support: Process and Perspective" - Major Jeffrey W. Cook

Handbook for Base Civil Engineering Operations Officers - Major Robert C. Frey

"A Demonstration LCOM Simulation of the Base Level Munitions Production Process" - Major Michael H. Gilchrist

Weapon Systems Acquisition Guide - Majors Vincent J. Lozito, Jr., and James W. Huffman

Great Strides with Small/Disadvantaged Business - Major Thomas R. Hunter

"The Attitudes of Aircraft Maintenance Personnel - A Profile" - Major Arnold L. Julich

"The Use of Warranties in the Acquisition of Conventional Munitions" - Major Bruce D. Mills

"Energy Conservation and the Power Factor Controller" - Major Michael K. Moritko

ATC Aircraft Maintenance Officer Handbook - Flying Training Activities - Major Raymond F. Morrissette

"Establishing a Second Source in Production" - Major Robert H. Shipman, Jr.

"Electric Vehicles - Inevitable?" - Major Chester L. Wallack

"Movement Control: Enhancing Defense Transportation System Support for Resupply During Contingency Operations" - Major Gregory D. Stubbs

---

Loan copies should be available by the end of the summer through the Air University Library, Interlibrary Loan Service (AUL/LDEX), Maxwell AFB, Alabama 36112. Additional information on the ACSC studies can be obtained through ACSC/EDCC, Maxwell AFB, Alabama 36112 (Autovon 875-2483; Commercial 205-293-2483).

The Fuel Efficient Missile Combat Crew Routing Network

Captain Edward O. Jacques, Jr.
Chief, Site Maintenance Branch
351st Organizational Missile Maintenance Squadron
351st Strategic Missile Wing
Whiteman AFB, Missouri 65305

Captain Michael G. Woolley
Sector Maintenance Officer
381st Strategic Missile Wing
McConnell AFB, Kansas 67221

Each day within the Strategic Air Command (SAC), missile combat crews (MCCs) dispatch from each of the nine strategic missile wing support bases (SMSBs) to launch control facilities (LCFs) in the surrounding area. Normal dispatch procedures have these MCCs drive government vehicles as their means of transportation between the strategic missile support base and the LCF.

Because the transport of MCCs is the highest mileage accumulator within SAC, this area of high energy consumption requires special attention within overall energy conservation efforts [22:1].

Excessive fuel consumption associated with the transportation of missile combat crews can be caused by a combination of using vehicles with inefficient fuel consumption characteristics over transportation networks that do not minimize distances traveled.

Background

Standard station wagons were the primary mode of transporting missile combat crews to the LCFs at all missile bases until 1972. This type of vehicle had a life expectancy of 70,000 to 90,000 miles, but had poor operating characteristics (i.e., poor steering, vehicle sway, and frequent bottoming-out when fully loaded with passengers and related equipment) [24:1]. The low-silhouette carryall was selected as the replacement for the station wagon and has remained the primary missile combat crew transport vehicle because of its flexibility, reliability, and long life of 170,000 to 200,000 miles. Although this vehicle has proved to be ideal for this transportation requirement, increased Environment Protection Agency requirements have resulted in larger engines and increased antipollution components which adversely affected fuel consumption. The 1979 model year low-silhouette carryalls have averaged only 9.5 miles per gallon as compared to prior year models which averaged over 12.0 miles per gallon [25:1].

Current MCC transport requirements vary from base to base. Each Titan base dispatches four-man MCCs to each of their 18 LCFs on a daily basis. Three to five of these MCCs are also accompanied by two-man Security Police Alert Response Teams. Each Minuteman base also dispatches a MCC to each of their 15 or 20 LCFs on a daily basis. The dispatch may include one two-man MCC destined for one LCF; two two-man MCCs destined for two separate LCFs; or one two-man MCC, accompanied by a cook and a facility manager (FM), destined for one LCF. A literature review, personal experience, and discussion with responsible personnel did not indicate that quantitative approaches have been used as decision-aiding tools for the development of dispatch routes designed to minimize distances traveled in the transportation network. Apparently, dispatch routes have evolved through the years based on qualitative criteria such as maintaining squadron integrity and the quality of life of the MCCs.

The Strategic Air Command Study

In 1979, SAC initiated a study to address the long-run fuel efficiency problem. Study members recognized that the low-silhouette carryall has proven to be an excellent vehicle with a good maintenance record, overall low cost per miles driven and high mileage life expectancy. However, the low fuel efficiency and variable crew/cargo composition of many dispatches no longer justified the use of the low-silhouette carryall in all situations. Therefore, "the most desirable mode of transportation may have to become secondary to the most fuel efficient mode" [22:2].

SAC approached the study from several different perspectives. First, SAC tasked the nine missile wings with using assigned compact station wagons and sedans for MCC transport whenever possible. These vehicles can be supplemented by low-silhouette carryalls when passenger/cargo requirements for inclement weather conditions dictate [22:2]. Second, a test program with six types of leased subcompacts at four missile bases was begun to evaluate this range of vehicles in different climatic conditions. The ultimate goal was to identify vehicles for future incorporation in a vehicle mix with low-silhouette carryalls [28:1]. Third, SAC asked HQ AFLC/LO to help in the procurement of more fuel efficient vehicles and to explore the possibility of more fuel efficient engines which could be used in the present fleet as replacement engines are required [25:1]. SAC also asked for assistance in raising the initial vehicle acquisition price ceiling based on fuel efficiency considerations within a life cycle cost framework for the procurement of these vehicles [25:2]. Finally, SAC began investigating diesel powered vehicles as well as alternative fuels that might be used to supplement or replace gasoline [24:4].

Moreover, the above aspects were to be considered in conjunction with other related factors such as:

(1) Missile Combat Crew "Quality of Life",
(2) Severe Weather Conditions,
(3) Vehicle Dispatch Mix,
(4) Vehicle Ground Clearance,
(5) Vehicle Maintenance and Acquisition Costs,
(6) Unimproved and Paved Roads,
(7) Crew Travel Related Time Costs,
(8) Personnel and Cargo Volume, and
(9) Weight Carrying Capability [7].

SAC's study is primarily oriented towards a long-term improvement of fuel efficiency of the SAC vehicle fleet. The dividends of this study are years away. In the meantime, managers must attempt to maximize the use of our available gasoline resources.

The Routing and Dispatch Problem

The SAC study does not address the specific dispatch procedures and routes of travel to and from each LCF because these factors are under the control of each individual missile wing commander. It is within this area that the current authors extended the study of fuel efficiency by looking at the routing networks used to dispatch the MCCs to the LCFs. Our study, accomplished at the Air Force Institute of Technology's School of Systems and Logistics during 1979-80, concentrated on the existing routes at one SAC missile base, Minot AFB, North Dakota. In the process, we first developed:

(1) The shortest authorized routes from the SMSB to the LCFs.

(2) The shortest authorized routes from any LCF to any other LCF.

Using this information, several routing networks were considered to determine:

(1) The shortest authorized route from the SMSB to several LCFs with subsequent return to the SMSB.

(2) The routing networks for available vehicles, given the constraints of the number of passengers demanded by the authorized route and the passenger/gear capacity of the vehicle.

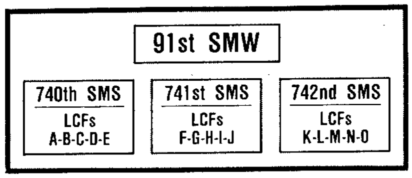
The criterion for measurement of the various routing networks was gallons of fuel used per passenger.

Through this criterion, the various routing networks generated were compared, in terms of fuel efficiency, to the present MCC routing network at the Minot AFB, North Dakota, test base. It was recognized that during the course of this research, modifications might occur in the existing system due to changes in dispatch procedures, road closings, or due to any number of other reasons. Therefore, in order to establish a single standard for comparison and to isolate out the interactive effects of future network modifications, the present MCC routing network was defined as that network and associated dispatch procedures in effect as of 31 August 1979.

The Present MCC Routing System

The MCC routing system in use at Minot AFB as of 31 August 1979 is within the guidelines established by the 91st Strategic Missile Wing, Deputy Commander for Operations, Operating Instructions 77-2 (38). In order to strike a balance between fuel and man-hour conservation, this operating instruction specifies the primary and alternate routes of travel to be used by MCCs when traveling to the LCFs. In the interest of fuel consumption, specific vehicle dispatch schedules are also identified for each of three possible dispatch requirements [38:1-2].

These three possible vehicle dispatch schedules are based on the requirement for facility manager and cook changeover at each LCF in a specific squadron and a desire to have these personnel travel with the MCC going to the same LCF. Each day, one of the three strategic missile squadrons (740th SMS, 741st SMS, or 742nd SMS) has a scheduled changeover of facility managers and cooks. This fluctuating requirement necessitates a flexible vehicle dispatch procedure. Therefore, each of the three possible vehicle dispatch schedules are specifically identified, and the proper schedule for any particular day is contingent on which strategic missile squadron has the scheduled changeover of facility managers and cooks [38].



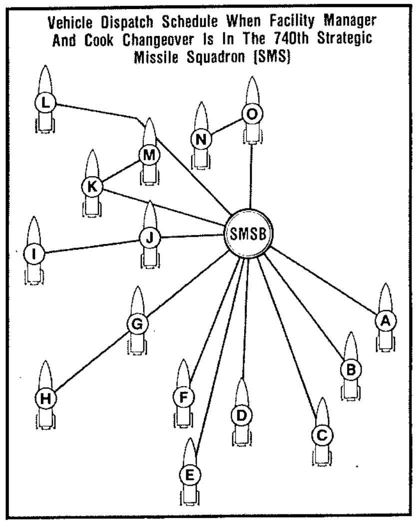


Figure 1. - Day 1

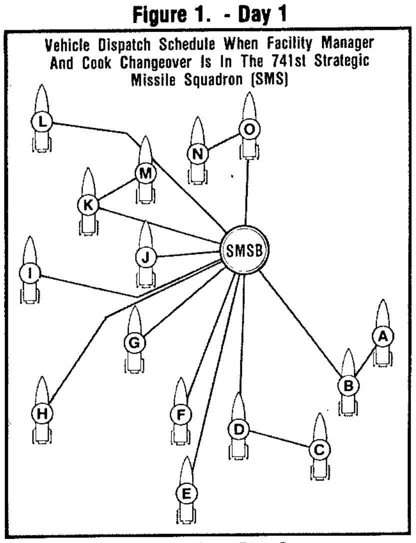


Figure 2. - Day 2

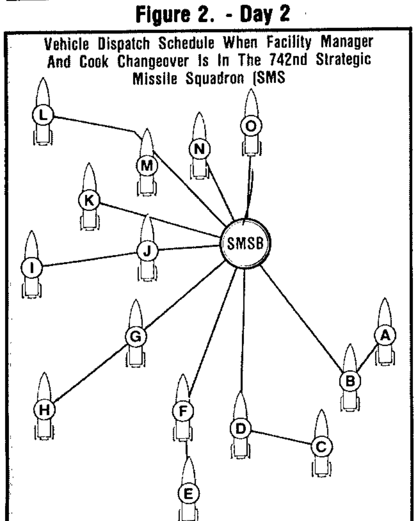


Figure 3. - Day 3

Figures 1, 2, and 3 show the three dispatch schedules of crew vehicles at Minot. Under the present vehicles dispatch scheduling system, a backtracking procedure is used. Each vehicle proceeds from the base to one or more LCFs to deliver relief personnel, and returns over the same route to pick up relieved personnel. Each vehicle presently carries one two-man MCC, two two-man MCCs, or one two-man MCC accompanied by a facility manager and cook [38]. Although the low-silhouette carryall crew vehicle can carry six personnel and their related gear, the present procedure never calls for more than four passengers in any vehicle on a regularly scheduled basis. This procedure provides flexibility for additional passenger requirements (training crew, evaluation crew, etc.) or additional equipment/housekeeping supplies. The present vehicle scheduling system satisfies driver requirements by using the MCC members in that capacity.

Because the 91st Strategic Missile Wing has three separate vehicle dispatch schedules, it was determined that the current gallons of fuel per passenger ratio could be computed only by looking at the total number of miles traveled over an entire 3-day changeover cycle. Each of the three schedules was reviewed, and distances were computed for the primary authorized routes of travel using the 91st Strategic Missile Wing (Wing III) Transport-Erector Route Book.

The route book contains all authorized routes for different vehicle types overlayed with a one square mile grid network. The distances between the SMSB and the LCFs, and the distances between the LCFs, were computed from this document. First, the distances for the existing routing system were computed (Table 1) by applying a mechanical divider to the routes of travel specified in the aforementioned Operating Instruction 77-2. However, these distances may or may not be the shortest distances between two specific points. Therefore, a "straight-line" methodology was applied to the Transport-Erector Route Book map of the 91st Strategic Missile Wing complex to determine the shortest distance between two points. With this "straight-line" methodology, a straight edge was placed on the map to link any two desired points. The shortest route between these two points was then determined by following a route of travel over authorized routes that correspond as closely as possible with the straightline connecting the two nodes. After determination of the shortest routes, the distances for these routes were computed as before using a divider and the Transport-Erector Route Book. These shortest distances were used as data inputs in the problem formulation.

Measure of Efficiency

The efficiency formula used within this study was one relating the number of gallons of fuel used to transport each MCC member, facility manager, or cook to the LCF. Its basic formulation is as follows:

(1) Compute the total number of miles (M_{total}) driven for each deployment strategy.

(2) Divide the total number of miles driven by the fuel efficiency of the vehicle used in the deployment strategy. The fuel efficiency of each vehicle is measured by the vehicle's miles per gallon (MPG) ratio. The result will be the total number of gallons (Gal_{total}) used within each deployment strategy/vehicle combination.

TABLE 1.
Present MCC Routing System Distances

Day 1 of 3-day Changeover Cycle - 740th SMS

Route	*Miles*	*People Transported*
SMSB - A - SMSB	116.00	4
SMSB - B - SMSB	101.00	4
SMSB - C - SMSB	120.50	4
SMSB - D - SMSB	93.00	4
SMSB - E - SMSB	134.50	4
SMSB - F - SMSB	114.50	2
SMSB-G-H-G-SMSB	194.50	4
SMSB-J-I-J-SMSB	118.50	4
SMSB-K-M-K-SMSB	126.50	4
SMSB - L - SMSB	142.00	2
SMSB-O-N-O-SMSB	93.00	4
	1354.00	40

Day 2 of 3-day Changeover Cycle - 741st SMS

SMSB-B-A-B-SMSB	156.00	4
SMSB-D-C-D-SMSB	132.00	4
SMSB - E - SMSB	134.50	2
SMSB - F - SMSB	114.50	4
SMSB - G - SMSB	150.00	4
SMSB - H - SMSB	154.50	4
SMSB - I - SMSB	120.00	4
SMSB - J - SMSB	64.00	4
SMSB-K-M-K-SMSB	126.50	4
SMSB - L - SMSB	142.00	2
SMSB-O-N-O-SMSB	93.00	4
	1387.00	40

Day 3 of 3-day Changeover Cycle - 742nd SMS

SMSB-B-A-B-SMSB	156.00	4
SMSB-D-C-D-SMSB	132.00	4
SMSB-F-E-F-SMSB	134.50	4
SMSB-G-H-G-SMSB	194.50	4
SMSB-J-I-J-SMSB	118.50	4
SMSB - K - SMSB	88.50	4
SMSB - L - SMSB	142.50	4
SMSB - M - SMSB	112.00	4
SMSB - N - SMSB	73.00	4
SMSB - O - SMSB	56.00	4
	1207.00	40

(3) The final step is to divide the total number of gallons of fuel used for each deployment strategy/vehicle combination by the total number of passengers ($Pass_{total}$) moved within the deployment strategy.

(4) Symbolically these efficiency formulas are:
(Equation)

(1) $$M_{total} = \sum_{i=1}^{3} M_i$$

(2) $$Gal_{total} = \frac{M_{total}}{MPG}$$

(3) $$Pass_{total} = \sum_{i=1}^{3} P_i$$

(4) $$\text{Gallons per passenger} = \frac{Gal_{total}}{Pass_{total}}$$

where, M_i = Miles driven on day i (i = 1, 2, 3) for a particular deployment strategy/vehicle combination.

M_{total} = Total miles driven for each deployment strategy.

Gal_{total} = Total gallons used within a deployment strategy/vehicle combination.

P_i = Passengers transported on day i for a particular deployment strategy/vehicle combination.

$Pass_{total}$ = Total passengers transported for each deployment strategy.

The present MCC routing system has an efficiency ratio of 3.46 gallons per passenger. It was computed using the information contained in Table 1 as follows:

(1) $M_{total} = 1354.00 + 1387.00 + 1207.00 = 3948.00$

(2) $Gal_{total} = \dfrac{3948.00 \text{ miles}}{9.5 \text{ MPG for low-silhouette carryall}} = 415.58$

(3) $Pass_{total} = 40 + 40 + 40 = 120$

(4) $\text{Gallons per passenger} = \dfrac{415.58 \text{ gallons}}{120 \text{ passengers}} = 3.46$

Obviously, this study focused on the types of vehicles that were available at Minot AFB (Table 2). Although there may not presently be sufficient numbers of each type of vehicle on hand for use in the MCC routing process, it is assumed that because these vehicles have previously met the test of congressional price ceilings, that additional vehicles of these types could be procured as replacements are required.

Survey of Principle Techniques

The MCC routing problem is one which falls within the scope of the well known sequencing theory problem called the Traveling Salesman Problem (TSP). The prototype TSP involves an individual who wishes to visit each of several given cities once and only once, and who also wishes to return to the starting point of his journey. The TSP has been given a great deal of study, and the literature reviewed has presented many treatises and analyses on the subject that deal with different methods to solve various TSPs. Two surveys of TSP literature, by Mole [30] and Bellmore and Nemhauser [2], were extremely helpful in directing the researchers to studies that might be applicable to the MCC routing problems [1, 6, 9, 10, 12, 13, 14, 15, 16, 18, 20, 23, 26, 27, 29, 31, 32, 33, 37].

Textbooks by Budnick, Mojena and Vollmann [4, 5] and Bradley, Hax and Magnanti [3] also gave further insight into the application of some possible solution techniques.

Deployment Strategies

Three basic deployment strategies (DS) were considered during the study.

DS I - "Arrive and Return"

The first deployment strategy (DS I) employs an "arrive and return" procedure called backtracking. With this strategy a vehicle proceeds from the SMSB to a location, or to a series of locations, and returns over the same path. The present MCC routing system at Minot AFB follows the premise of this deployment strategy. Figures 1, 2, and 3 show the backtracking routes for each day of the 3-day changeover cycle. In some situations, a vehicle departs the SMSB to one LCF and returns over the same route with the relieved personnel. In other situations, a vehicle departs the SMSB with two destinations. The vehicle proceeds to the first LCF and drops off the MCC. This delivery process entails approximately five minutes. The vehicle then proceeds to its second destination. After the crew changeover has been completed at the second LCF, which takes approximately one hour, the releived MCC backtracks the route to pick up the relieved crew at the first destination and the two MCCs return to the SMSB. The apparent advantages to this strategy are that crew members can accomplish the driving to and from the LCF without the need of a separate driver and that a complete wing changeover can be accomplished each day. The apparent disadvantage is that the number of vehicles required to accomplish the wing changeover is greater than with other deployment strategies under investigation.

DS II - "Arrive and Wait"

The second deployment strategy (DS II) does not employ the concept of backtracking, but rather an "arrive and wait" procedure. With this strategy, a vehicle departs the SMSB to an LCF. Upon arrival, the vehicle "waits" for the newly delivered MCC to replace the on-duty MCC. This changeover process takes approximately one hour. The relieved MCC then accompanies the vehicle to the next LCF. This "arrive and wait" process is repeated until all desired locations have been visited, and then the vehicle returns to the SMSB. This process does not allow for the return to any previously visited LCFs. Its apparent advantages are that crewmembers can accomplish the driving to and from the LCF and that the total number of miles is reduced. However, its apparent disadvantage is that the process results in one hour waits at each LCF visited that are in addition to the required travel time. This reduces the number of LCFs that could be visited each day and might adversely affect crew availability for future alert scheduling requirements.

Table 2.
Presently Available Vehicles (7)

Vehicle Type	*MPG Rating*	*Estimated Passenger Capacity**
Low-silhouette Carryall	9.5	6
Compact Station Wagon	18.0	4
15 Passenger Commuter Van	7.0	12**
29 Passenger Bus	6.0	22**
45 Passenger Bus	3.5	36**

*This includes MCCs, FMs, and cooks only. Motor pool drivers needed for Decision Strategy III are considered to be integral to the vehicle in use and do not impact on the estimated passenger capacity of any vehicle.

**Passenger capacity modification would be required to enable the vehicle to also carry the personal gear associated with each crew member, facility manager, and cook (technical order bag, survival gear, and/or personal items), survival kits, and periodic housekeeping supplies carried by the facility managers. The rear seat would be removed in the vans, while the last row and one of the two seats in the second-to-last row would be removed in the two types of buses.

DS III - "Trailing"

The third deployment strategy (DS III) that will be investigated is one that uses a trailing vehicle. A vehicle driven by a motor pool driver dispatches from the SMSB carrying MCCs destined for several LCFs. The vehicle proceeds to each LCF and drops off a MCC. As previously mentioned, this delivery process takes approximately five minutes. The vehicle continues to the next location and delivers the MCC. The process continues until all MCCs are deployed. At this point the vehicle returns to the SMSB without any relieved MCCs. One hour (the approximate length of a MCC changeover) after the first vehicle departed to deliver the new MCCs, a second vehicle is dispatched over the same route to pick up the relieved MCCs and return them to the SMSB. The apparent advantages of this procedure are that the MCCs are promptly and efficiently picked up for return to the SMSB and more LCFs could be visited each day with fewer vehicles. The apparent disadvantages of this procedure are that motor pool drivers would be required to drive the vehicles and the total number of miles driven would increase.

The important thing to recognize in evaluating the advantages and disadvantages of these deployment strategies is that they must be viewed in context with the whole model. Although total miles may increase with the selection of a strategy, they may be more than offset by use of a vehicle with a much higher miles per gallon ratio. This study evaluated these strategies in terms of the entire effect of the strategy and the associated vehicles on the gallons per passenger ratio.

Problem Formulation

The minimum distance TSP can be formulated as a 0-1 integer programming problem. The decision variable X_{ij} is an indicator variable that represents whether or not the link from node i to node j is included in the minimum tour (the shortest route through the network). X_{ij} equals one (1) if the tour includes the link from node i to node j, and X_{ij} equals zero (0) when the link from node i to node j is not included in the minimum tour. C_{ij} is the distance or "cost" associated with including the link from node i to node j in the tour. The objective is to minimize the tour distance or "cost," and becomes in general form:

$$\text{(5)} \qquad \text{Minimize } Z = \sum_{i}^{n} \sum_{j}^{n} C_{ij}X_{ij}$$

where n equals the number of nodes (including the starting point) in the network.

There are three sets of constraints typically associated with the Traveling Salesman Problem [4:286]. The first set of constraints is introduced to assure each city is visited exactly one time. The general formula for these constraints is:

$$\text{(6)} \qquad \sum_{\substack{i=1 \\ i \neq j}}^{n} X_{ij} = 1 \text{ for } j = 1,2,\ldots,n$$

The second set of constraints assures there is exactly one departure from each of the n nodes. The general formula for these constraints is:

$$\text{(7)} \qquad \sum_{\substack{j=1 \\ j \neq i}}^{n} X_{ij} = 1 \text{ for } i = 1,2,\ldots,n$$

The third set of constraints is used in order to prevent subtours (a tour which does not visit each node in the system at least once). These constraints state that if the link from node i to node j is included in the tour, then the link from j to i is excluded. For example, to prevent a subtour between nodes 1 and 2, the constraint:

$$\text{(8)} \qquad X_{12} + X_{21} \leq 1$$

would be used.

In the problems where the number of nodes (n) is even, the number of constraints needed to prevent subtours increases at an increasing rate corresponding to the formula (5:131):

$$\text{(9)} \qquad \frac{n!}{(n-2)!2} + \frac{n!}{(n-3)!3} + \cdots\cdots\cdots + \frac{n}{(n-\frac{n}{2})!\frac{n}{2}}$$

Equation 9 indicates that for an n of 16 (15 LCFs and the SMSB), 74,179,552 of the third type of constraints would be required. In problems where the number of nodes is odd, the number of subtour constraints required is even greater.

There are two integer programming programs in the Honeywell library that were available to the researchers. INT01 can handle only 11 constraints and INTLP can handle only 16 constraints [34]. Because of these limitations on problem size, neither of these programs could handle the 74,179,552 subtour constraints required in the MCC routing problem. The search was then directed towards finding another type of algorithm which could be employed to solve the MCC routing system problem. A "branch and bound algorithm", developed by Little, Murty, Sweeney, and Karel to solve TSPs, was found that showed promise [26]. It is a tour-building algorithm that calculates the minimum distance (lower bound) through a matrix reduction procedure. Because of the similarity of the Traveling Salesman Problem and DS II, this TSP algorithm was applied to the DS II phase of our MCC analysis.

Two problems exist within DS II. The first is the passenger/gear capacity of presently available vehicles at Minot AFB. The maximum passenger/gear capacity is maintained by a bus that can transport thirty-six passengers and their associated gear. Because the daily changeover requirement at Minot AFB is 40 personnel, the largest vehicle is not adequate to deploy all relief personnel in one trip. The second problem is one of time. Because it takes approximately one hour for MCC changeover, DS II will entail 15 hours of "waiting time" in addition to the time required for driving the total circuit. A rough estimate of the mileage from the base through all the LCFs and back to the base is 425 miles. If travel could be accomplished at a constant 55 miles per hour (which is not possible because some travel would be required on gravel roads where a 25 miles per hour speed limit is in force), it would take approximately 23 hours to complete the circuit. In addition to the excessive delay for relieved MCCs, current directives only allow a driver 8 hours of driving per 24-hour period [11].

Because of vehicle capacity constraints and the travel time constraints to complete the circuit, the wing complex was partitioned into smaller segments. A geographical partitioning procedure similar to Held and Karp's global partitioning procedure [20], was used which considered the geographical location of the LCFs, the personnel requirements for the LCFs on each day of the 3-day changeover cycle, and the personnel capacity restrictions of the vehicle under study. The authors evaluated these factors and developed partitions that would maximize vehicle capacity (to reduce the total number of vehicles required) as much as possible.

After development of the required partitions, the appropriate algorithm was used to develop the shortest authorized route network for each deployment strategy. For DS II, the appropriate distances associated with the shortest authorized routes between the SMSB and the LCFs and between the LCFs were input into Heidler's computer program [19] of the Little Branch and Bound algorithm to determine the shortest authorized route networks and the route distances. Because of the "trailing vehicle" concept of DS III, the shortest authorized route networks for DS III were the same as those for DS II, but the route distances were twice that of DS II. Heidler's model solves the general Traveling Salesman Problem where a vehicle proceeds from a starting point and visits each node only once and subsequently returns to the starting point. However, Heidler's computer model does not solve the "arrive and return" procedure (backtracking) inherent to DS I. With the backtracking procedure of DS I, a vehicle proceeds from a starting point and visits each node. The vehicle stops at the last node in the network and returns to the starting point via the reverse route. Figure 4 and Figure 5 give pictorial representations of these concepts.

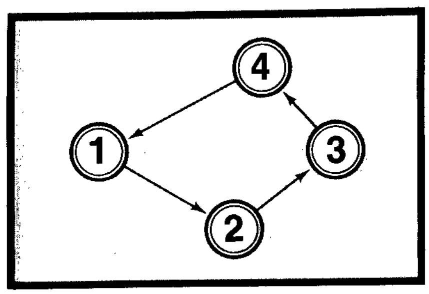


Figure 4.
Traveling Salesman

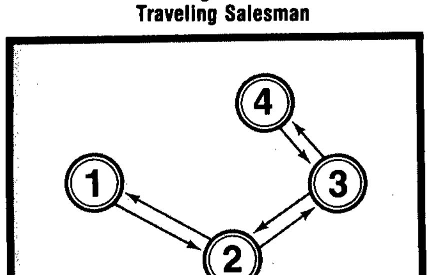


Figure 5.
Backtracking

The authors developed the following heuristic to handle the multiple visits required by the backtracking procedure. It is based on the symmetrical property of Little's Branch and Bound Algorithm.

Step 1: Solve the routing problem using the Heidler computer program. It will yield two equivalent solutions because of the symmetric property.

Step 2: Select the solution that has the longest last link (the link from the last LCF back to the SMSB).

Step 3: Subtract the last link from that solution. This provides the shortest tour that visits all nodes without returning to the starting point.

Step 4: Multiply the result by two. This will incorporate the "backtrack" and will provide the least total distance for that routing problem.

The total distances, number of gallons of fuel used, and the gallons per passenger efficiency formulation for each vehicle/deployment strategy combination for each 3-day changeover cycle are summarized in Tables 3, 4, and 5. The results of the investigation indicate that 10 of the 15 vehicle/deployment strategy combinations provide greater fuel efficiency than the 3.46 gal/pax of the present MCC routing system.

Table 3.
Vehicle/Deployment Strategy Summary
(Total Miles)

Type of Vehicle	*DS I*	*DS II*	*DS III*
Carryall	3,265.00	2,961.00	5,922.00
Station Wagon	3,635.50	3,511.75	7,023.25
Van	2,500.50	1,894.75	3,789.50
29 Pax Bus	2,266.00	1,424.50	2,849.00
45 Pax Bus	2,166.00	1,353.00	2,706.00

Table 4.
Vehicle/Deployment Strategy Summary
(Gallons of Fuel Consumed)

Type of Vehicle	*DS I*	*DS II*	*DS III*
Carryall	343.68	311.68	623.37
Station Wagon	201.97	195.10	390.18
Van	357.21	270.68	541.36
29 Pax Bus	377.67	237.42	474.83
45 Pax Bus	618.86	386.57	773.14

Table 5.
Vehicle/Deployment Strategy Summary
(Gallons per Passenger)

Type of Vehicle	*DS I*	*DS II*	*DS III*
Carryall	2.86	2.60	5.19
Station Wagon	1.68	1.63	3.25
Van	2.98	2.26	4.51
29 Pax Bus	3.15	1.98	3.96
45 Pax Bus	5.16	3.22	6.44

Analysis of Data

Table 6 provides a comparison of the potential savings of the fifteen vehicle/deployment strategy combinations over the MCC routing system in effect as of 31 August 1979. The table includes the number of gallons of fuel saved (lost) and the percent savings (percent loss) by conversion to the particular vehicle/deployment strategy combination. The number of gallons of fuel saved (lost) and the percent savings (percent loss) were derived as shown by equations 10 and 11 at right (below Table 6).

Table 6.
Potential Savings Per 3-Day Changeover Cycle
(Gallons of Fuel-Percent Savings)

Type of Vehicle	*DS I*	*DS II*	*DS III*
Carryall	71.9/17%	103.00/25%	(207.79)/(50%)
Station Wagon	213.61/51%	220.48/53%	25.40/6%
Van	58.37/14%	144.90/35%	(125.78)/(30%)
29 Pax Bus	37.91/9%	178.16/43%	(59.25)/(14%)
45 Pax Bus	(203.28)/(49%)	29.01/7%	(357.56)/(86%)

$$\text{(10)}\quad \begin{array}{l}\text{Gallons of fuel}\\ \text{consumed with}\\ \text{present system}\end{array} - \begin{array}{l}\text{Gallons of fuel}\\ \text{consumed with}\\ \text{proposed system}\end{array} = \begin{array}{l}\text{Gallons saved}\\ \text{(Gallons lost)}\end{array}$$

$$\text{(11)}\quad 1 - \frac{\begin{array}{l}\text{Proposed system}\\ \text{efficiency ratio}\end{array}}{\begin{array}{l}\text{Present system}\\ \text{efficiency ratio}\end{array}} \times 100\% = \begin{array}{l}\text{Percent saved}\\ \text{(Percent lost)}\end{array}$$

Our analysis indicates that five vehicle/deployment strategy combinations are less efficient than the present MCC routing system and are excluded from further consideration. These combinations include Carryall/DS III, Van/DS III, 29 Pax Bus/DS III, 45 Pax Bus/DS I, and 45 Pax Bus/DS III.

Closer analysis of the remaining ten vehicle/deployment strategies indicates that although a vehicle/deployment strategy is more efficient in terms of gallons per passenger, the choice of that combination may necessitate additional resource requirements that are beyond the existing capabilities of the base resources and may result in incremental costs which prove prohibitive. Analysis based on this criteria eliminated the following six combinations: Station Wagon/DS III, 29 Pax Bus/DS II, 45 Pax Bus/DS II, Van/DS II, Van/DS I, and 29 Pax Bus/DS I. The potential lengthy travel times, driving safety factor, vehicle and manpower resource requirements, and prohibitive incremental costs associated with these six vehicle/deployment strategy combinations are currently more disadvantageous than advantageous.

The four remaining vehicle/deployment strategy combinations are all acceptable and preferable alternatives to the present MCC routing system.

The Carryall/DS I combination is similar to the present MCC dispatching system. The 17% improvement to 2.86 gallons per passenger is the result of increased passenger capacity from four to six, and the development of the shortest authorized routes of travel that replace the present emphasis on the use of paved roads. The Carryall/DS II combination provides a 25% savings by using shorter routes of travel and the "arrive and wait" procedure. The additional time associated with DS II adds only two hours to the "total" travel time of any network (resulting from the additional wait at two LCFs). The Station Wagon/DS I combination provides potential fuel savings of 51% as the result of its 18 miles-per-gallon rating and the shorter authorized routes of travel. Even though the total number of miles per 3-day changeover cycle for this combination is the largest of the four acceptable combinations, the increased fuel economy of the station wagon provides the second-best fuel efficiency ratio of 1.68 gallons per passenger. The Station Wagon/DS II combination provides the best overall results and provides a potential 53% fuel savings over the present MCC routing system. The "arrive and wait" nature of this combination would only result in the addition of one hour to the "total" travel time of the tour provided in the Station Wagon/DS I combination.

Conclusions

The authors believe that the Station Wagon/DS II vehicle/deployment strategy (coupled with travel over the shortest authorized routes of travel), and its potential 53% fuel savings, would be the best choice to replace the present MCC routing system at Minot AFB, North Dakota.

The following analysis demonstrates the potential benefits of this recommendation when considered over a one year time horizon. The present MCC routing system uses 415.58 gallons of fuel for each 3-day changeover cycle, as compared to 195.10 gallons with the Station Wagon/DS II combination. The net potential savings are 220.48 gallons for each 3-day changeover cycle. With 121.67 3-day changeover cycles per year, the potential fuel savings amount to 26,826 gallons of fuel per year. With the present escalation in the price of fuel, the impact of the quantity of fuel saved is magnified by its potential savings in fuel costs. The potential yearly fuel savings for the four acceptable vehicle/deployment strategy combinations were similarly computed and are summarized in Table 7.

Table 7.
Potential Yearly Savings of Fuel in Gallons

Vehicle Type	*DS I*	*DS II*
Carryall	8,748	12,642
Station Wagon	25,990	26,826

It must be remembered that these potential results were a composite of the effects of the vehicle/deployment strategies, the miles-per-gallon rating of the vehicle, and the development of the shortest authorized routes of travel. These potential savings must be tempered by a recognition that they are based on day-to-day use of the shortest authorized routes of travel and the transporting of only the required LCF personnel. Severe weather, gravel and paved road conditions, and additional LCF personnel (training crews, standardization crews, visitors, etc.) may all have negative impacts on the potential savings of any of the four accepable vehicle/deployment strategy combinations. Thus, the flexibility to meet these contingencies may prevent the actual attainment of the estimated potential savings for any vehicle/deployment strategy combination that would be used in conjunction with the shortest authorized routes of travel. However, following the shortest authorized routes of travel as often as possible will reduce overall fuel consumption.

Recommendations

The next step in the comparison of the present MCC routing system with the four acceptable alternatives should be to independently implement the four alternatives on a trial basis to see if practical application of the procedures described in this study perform in the same manner as the study predicts. Because Minot AFB's forty-seven carryalls [7] are enough to effect wing-wide implementation of the Carryall/DS I or Carryall/DS II combinations, practical tests of these MCC routing systems over the shortest authorized routes could be done throughout the entire wing or just with a segment (such as a squadron) of the wing. Because Minot AFB's eight station wagons [7] do not meet the needs of eleven vehicles for the Station Wagon/DS I or Station Wagon/DS II combinations, the practical tests of these MCC routing systems over the shortest authorized routes could be done through rotating segments that will aggregate to a test of entire wing. If the results correspond to the research results, all available compact station wagons could be dedicated to the routing of MCCs, with the less efficient carryalls picking up the vacated transportation responsibilities, and additional compact station wagons could be purchased as existing vehicle assets required replacement.

Other Areas for Investigation

Although the overall SAC study investigated many related factors such as alternative fuels, alternative vehicle types, and MCC "quality of life" factors, several areas appear to be logical extensions of this research. An increase in the number of passengers carried in a vehicle might reduce the total number of miles and the number of vehicles required. This might be achieved through the use of cargo roof racks or other vehicle modifications. An example of the potential of this area of study can be seen by modifying the compact station wagon to carry 6 personnel. The compact station wagon could then follow the same routes as the Carryall and the fuel efficiency ratios for DS I, DS II, and DS III would drop to 1.51 gal/pax, 1.37 gal/pax, and 2.74 gal/pax, respectively. These lower fuel efficiency ratios would enhance the fuel savings to 28,471 gallons, 30,561 gallons and 10,559 gallons for DS I, DS II, and DS III.

Another area that could be investigated is the dispatching of Security Police personnel with the other LCF personnel. This would be another excellent means to cut down on overall miles traveled, fuel consumption, and vehicle requirements. Since Security Police personnel transit to the same LCFs as the MCCs, FMs, and cooks, the potential for additional wing savings might occur by coordinating the movement of all required LCF personnel in the same vehicle rather than continuing the present system of multiple vehicle visits to the same LCF.

A third potential area for investigation is the concept of a vehicle mix. While the SAC study encompasses the concept of vehicle mix with new vehicles, a mix of the vehicles presently on hand should be analyzed to see if further economies can be achieved by using the best vehicle for each particular situation or network.

A fourth area that may be investigated is an elimination of the requirements for facility manager and cook changeover by squadrons. For example, after the present research was well underway, it came to our attention that the 91 SMW changed the present deployment strategy, which was used for comparison purposes in our research, to remove squadron integrity in facility manager and cook changeovers. The authors recognize that the resultant increased utilization of the carryall with six passengers can save gasoline resources, but that use of the same routes that were in effect as of 31 August 1979 does not result in maximizing fuel savings. It is recommended that this recent change to the present MCC routing system at Minot AFB be analyzed in conjunction with use of the shortest authorized routes developed in this study to determine if further savings can be achieved.

A final area for potential investigation is to change the 24-hour alert tour to a 48 or 72-hour alert tour. A decrease in fuel consumption would directly correspond with these longer alerts. For example, an increase to a 48-hour alert tour would cut gasoline consumption for comparable MCC routing systems by one-half, while an increase to a 72-hour alert tour would cut gasoline consumption by two-thirds. Such changes in dispatch procedures would further enhance the results identified in this research. However, the reduced gasoline requirements would have to be weighed against behavioral and physical factors such as crew member morale and fatigue to determine if the benefits of such a change outweigh the costs.

This study attempted to look at the short-term problem of using the existing vehicle types at Minot AFB in the most efficient manner possible. Through the development of the shortest authorized routes of travel and fifteen vehicle/deployment strategy combinations, this study has demonstrated the potential for fuel savings of up to 53% in routing MCCs to the LCFs at Minot AFB, North Dakota. In addition, the development of the shortest authorized routes of travel should complement and enhance the findings of the SAC study by providing the shortest distances for any new or modified vehicles in the future.

The potential for savings at each missile base exists, and the methodology developed in this study appears to be capable of implementation at any of them. Any opportunity for potential fuel savings cannot be overlooked, and other SAC missile bases should consider applying this methodology in an effort to reduce their gallons per passenger fuel efficiency ratio.

References

[1] Bellman, Richard. "Dynamic Programming Treatment of the Traveling Salesman Problem," *Journal of the Association for Computing Machinery*, January 1962, pp. 61-70.

[2] Bellmore, M. and Nemhauser, G. L. "The Traveling Salesman Problem: A Survey," *Operations Research*, May-June 1968, pp. 538-558.

[3] Bradley, Stephen P., Arnoldo C. Hax, and Thomas L. Magnanti. *Applied Mathematical Programming*. Phillipines: Addison-Wesley Publishing Company, Inc., 1977.

[4] Budnick, Frank S., Richard Mojena, and Thomas E. Vollmann. *Principles of Operations Research for Management*. Homewood IL: Richard D. Irwin, Inc., 1977.

[5] ________________ . *Instructor's Manual for Principles of Operations Research for Management*. Homewood IL: Richard D. Irwin, Inc., 1977.

[6] Christofides, N. "The Vehicle Routing Problem," *Revue Francaise d'Automatique, d'Informatique et de Recherche Operationelle*, Vol 10, February 1976, pp. 55-70.

[7] Cox, Captain Randy, USAF. Action Officer, HQ SAC/LGTV, Telephone interview, subject: SAC Missile Combat Crew Fuel Efficiency Study, 30 August 1979.

[8] Dagner, Lyle A. Chief Missile Engineer, 91st Strategic Missile Wing/CES. Telephone interview, subject: Transport-Erector Route Book, 1 November 1979.

[9] Dantzig, G. B., D. R. Fulkerson, and S. M. Johnson, "Solution of a Large Scale Traveling Salesman Problem," *Operations Research*, November 1954, pp. 393-410.

[10] Dantzig, B. and Ramser, J. H. "The Truck Dispatching Problem," *Management Science*, October 1959, pp. 80-91.

[11] Davis, Technical Sergeant Glenn A., USAF. Chief Dispatcher, 91st Strategic Missile Wing/LGT. Telephone interview, subject: Limitations on Vehicle Drivers, 15 November 1979.

[12] Eastman, W. L. "Linear Programming With Pattern Constraints," PhD. Dissertation, Harvard, 1958.

[13] Eilon, S. and Christofides, N. "An Algorithm for the Vehicle Dispatching Problem," *Operational Research Quarterly*, September 1969, pp. 309-318.

[14] Gilmore, P. C. and Gomory, R. E. "Sequencing a One-State Variable Machine: A Solvable Case of the Traveling Salesman Problem," *Operations Research*, September/October 1964, pp. 655-679.

[15] Gomory, R. E. "An Algorithm for Integer Solutions to Linear Programs," *Recent Advances in Mathematical Programming*. New York: McGraw-Hill, 1963, pp. 269-302.

[16] Gonzales, R. H. "Solution to the Traveling Salesman Problem by Dynamic Programming on the Hypercube," Technical Report No. 18, O. R. Center, M.I.T., 1962.

[17] Grant, Captain Douglas A., USAF, Former Missile Maintenance Officer at Whiteman AFB, MO. Personal interview, 14 November 1979.

[18] Hatfield, D. J. and Pierce, J. F. "Production Sequencing by Combinatorial Programming," IBM Cambridge Scientific Center, Cambridge, Massachusetts, 1966.

[19] Heidler, Captain Claire D., USAF. "A Review of the Closed Circuit Problem," Unpublished term paper, AFIT/SL, Wright-Patterson AFB OH, May 1975.

[20] Held, Michael and Karp, Richard M. "A Dynamic Programming Approach to Sequencing Problems," *Journal of the Society for Industrial and Applied Mathematics*, March 1962, pp. 196-210.

[21] Horne, Major, USAF. Action Officer, Energy Management Branch, HQ USAF/LEYSF. Telephone interview, subject: Presidential Memorandum on the Reduction of Energy Use, 15 October 1979.

[22] HQ SAC/LG/DO Message, 132115Z June 1979. Subject: Fuel Efficient Vehicles in High Mileage Operations. OPR: HQ SAC/LGTV.

[23] Karg, Robert L. and Thompson, Gerlad L. "A Heuristic Approach to Solving Traveling Salesman Problems," *Management Science*, January 1964, pp. 225-248.

[24] Light, Brigadier General James E. Jr., USAF. Deputy Chief of Staff Logistics, HQ SAC/LG. Point paper, subject: Missile Crew Transportation, to HQ SAC/CV, 21 May 1979.

[25] ________________. Letter, subject: Fuel Efficient Vehicles, to HQ AFLC/LO, 4 June 1979.

[26] Lin, Shen. "Computer Solutions of the Traveling Salesman Problem," *The Bell System Technical Journal*, December 1965, pp. 2245-2269.

[27] Little, John D., Katta G. Murty, Dura W. Sweeney, and Caroline Karel. "An Algorithm for the Traveling Salesman Problem," *Journal of Operations Research*, November-December 1963, pp. 972-989.

[28] Longsworth, Colonel T. W., USAF. Acting Assistant Deputy Chief of Staff Logistics, HQ SAC/LG. Point paper, subject: Use of Subcompact Vehicles to Support Missile Crews, to HQ SAC/CV, 27 June 1979.

[29] Miller, C. E., A. W. Tucker, and R. A. Zemlin. "Integer Programming Formulation of Traveling Salesman Problems," *Journal of the Association for Computing Machinery*, 1960, pp. 326-329.

[30] Mole, R. H. "A Survey of Local Delivery Vehicle Routing Methodology," *Journal of the Operational Research Society*, March 1979. pp. 245-252.

[31] Pierce, J. F. "Direct Search Algorithms for Truck Dispatching Problems," *Transportation Research*, Vol 3, pp. 1-42.

[32] Reiter, S. and Sherman, G. "Discrete Optimizing," *Journal of the Society for Industrial and Applied Mathematics*, Vol 13 (1965), pp. 864-889.

[33] Shapiro, D. "Algorithms for the Solution of the Optimal Cost Traveling Salesman Problem," ScD. Thesis, Washington University, St. Louis MO, 1966.

[34] Stewart, Major Todd I., USAF. Assistant Professor of Management Science, AFIT/SL. Personal interview, subject: Integer Programming, 9 December 1979.

[35] Transport-Erector Route Book, Wing III, 91st Strategic Missile Wing, Minot AFB ND.

[36] Whiting, P. D. and Hillier, J. A. "A Method for Finding the Shortest Route Through a Road Network," *Operational Research Quarterly*, March-June 1960, pp. 37-40.

[37] Yellow, P. C. "A Computational Modification to the Savings Method of Vehicle Scheduling," *Operational Research Quarterly*, June 1970, pp. 281-283.

[38] 91st Strategic Missile Wing, Deputy Commander for Operations, Operating Instruction 77-2, Subject: Crew Vehicle Dispatch Procedures and Travel Routes To/From LCFs, 30 August 1979.

Related Sources

Leavitt, Lieutenant General Lloyd R., Jr., USAF. Vice Commander In Chief Strategic Air Command, HQ SAC/CV. Memo, subject: Fuel Efficient Vehicles, to HQ SAC/LG, 23 April 1979.

________________. Memo, subject: Fuel Efficient Vehicles, to HQ SAC/LG, 1 May 1979.

________________. Memo, subject: Fuel Efficient Vehicles, to HQ SAC/LG, 3 May 1979.

Light, Brigadier General James E. Jr., USAF. Deputy Chief of Staff Logistics, HQ SAC/LG. Point paper, subject: Diesel Engines for Vehicles, to HQ SAC/CV, 26 April 1979.

Lin, S. and Kernighan, B. W. "An Effective Heuristic Algorithm for the Traveling Salesman Problem," *Operations Research*, March-April 1973, pp. 498-516.

Lindsey, Colonel Clarence H., USAF. Director of Transportation, Deputy Chief of Staff Logistics, HQ SAC/LGT. Point paper, subject: Fuel Efficient Vehicle Test, to HQ SAF/LG, 14 September 1979.

Roberts, S. M. and Flores, B. "An Engineering Approach to the Traveling Salesman Problem," *Management Science*, November 1966, pp. 269-288.

Russell, Robert A. "An Effective Heuristic for the M-tour Traveling Salesman Problem With Some Side Conditions," *Operations Research*, May-June 1977, pp. 517-524.

Van Denberg, Captain David R., USAF, and Veith, Captain Jon D., USAF. "Optimal Placement of Regional Flight Simulators." Unpublished master's thesis. LSSR 18-78B, AFIT/SL, Wright-Patterson AFB OH, September 1978.

Network Analysis continued from page 15

Throughout industry and government, managers are often put in charge of a project without knowing all the details involved. For these many managers, the model networks become a roadmap to follow until they gain the experience to be more creative and tailor the network. The models make it possible for them to see which tasks may be required and what the interrelationships are. Using this system, more new managers will swim rather than sink. None can afford failures.

The model ILS networks contain key tasks/events from all the ILS elements and other key activities such as the Government Furnished Equipment or Contractor Furnished Equipment decision process, depot and site activation/deployment planning, program management responsibility transfer, etc.

In addition to program management, the model networks serve other uses. They make an excellent learning tool. The magic of the software combined with the model networks is related to the adage that "a picture is worth a thousand words." Training classes can "see" a graphic acquisition program and the interdependencies of the elements therein. These classes may then learn networking and acquisition management by experimenting with and tailoring on the model to learn and possibly discover improved methods.

One of the major problems in acquisition management is fielding new systems in less time. The number of years from program initiation to delivery of a new system can be excessive. This excessive time can cause cost overruns due to inflation; and problems when new technology advances occur faster than system development resulting in a new but outmoded system. As experience is gained in model networking, primary time drivers can be found and the manager can concentrate on reducing them in order to develop improved plans to field new systems in less time.

Current/Future Applications

This system of software and model networks is being applied in many ways to many projects. It is being used to develop the ILS plan for the MX Missile, Next Generation Trainer, and the CX Transport, and will be used on future programs. It is also being used for the Cruise Missile depot activation planning, F-100 site activation planning, and other management problems. The AFALD is anticipating that this software and model network combination will become the standard for all future project planning within AFALD. As managers gain experience, additional capability to add management data such as costs and resources, will increase the utility of the networks. As data are added it becomes simple to produce additional computer reports and graphs. For example, if costs per network task are added to the data base a cost trend analysis can be generated related to network times and tasks.

Summary

The applications of networking are endless. Any project that involves multiple tasks must be planned out and have some method of tracking the progress of those tasks. Any project/program manager that does not plan is not an effective manager. Networking is the only form of planning that can effectively consider the interdependencies of the tasks which dictate the timing of those tasks. The developed software and the model networks simplify the networking task to the point that managers have no excuse for not networking. The man-hours we are saving by networking are tremendous. The ultimate proof of the value of this management tool will come in the form of higher readiness of the weapons in the hands of our fighting forces.

The 1981 Dudley C. Sharp Award

Senior Master Sergeant Charles D. Back has been designated by the Secretary of the Air Force and the Air Force Chief of Staff as the 1981 recipient of the Dudley C. Sharp Award for outstanding achievement in logistics. SMSgt Back developed and tested a Centralized Aircraft Support System which provides aircraft starting air from a central pad to flight line stations. Through introduction of this system, there is a projected life cycle cost savings of over $75 million in personnel, fuel and maintenance costs for the Air Training Command and potential for application Air Force wide, by other Services and by other countries.

International Logistics in AFLC During 1980

The International Logistics Center (ILC) is responsible for overall operation of AFLC Security Assistance (SA) programs. The ILC Commander serves also as the Assistant to the Commander of AFLC for International Logistics.

The AFLC SA program is comprised of Foreign Military Sales (FMS) and Grant Aid projects. Grant Aid projects are congressionally appropriated military assistance programs to friendly countries whereas FMS are direct case sales.

During 1980, the ILC managed FMS programs for more than 60 friendly foreign countries totalling $11.8 billion. Manpower increased to over 400 civilian and military personnel.

Middle East/Africa

The SA program for the Royal Saudi Arabian Air Force (RSAF) is one of our major programs in the ILC. The Peace Sun program consists of five separate programs - Peace Sun I through Peace Sun V. The Peace Sun program provides for 45 F-15C and 15 F-15D aircraft, 909 AIM-7F and 842 AIM-9P-3 missiles, support equipment, three years initial spares, and funding for construction and in-country support. Peace Sun II and III include facility modification and construction required to support F-15 aircraft at three RSAF bases, organizational and intermediate maintenance, and an RSAF self-sufficiency training program. Peace Sun IV covers Continental United States training for RSAF Pilots, maintenance technicians, and officers. Peace Sun V, valued at $54.6 million, will provide for two F-15C attrition aircraft with delivery scheduled for CY 1983.

Three major Egyptian programs are Peace Reed, Peace Pharaoh and Peace Vector. Peace Reed provides for follow-on support of 19 C-130 aircraft. The Peace Pharaoh program was established for the sale of 35 F-4E aircraft and related support equipment and spares. The last 19 aircraft were delivered during the first quarter of 1980. Shipment of the required support equipment for one base began in January 1980. Peace Vector is for the sale of 40 F-16s beginning the first quarter of 1982. AFLC handled 132 cases for the Egyptian Air Force during 1980 accounting for $809 million.

The Israeli program consists of 190 active cases valued at $757 million. One of the more significant programs is Peace Marble. This program provides for the sale of 75 F-16 aircraft and related support equipment and spares. Deliveries of the aircraft started in July 1980. There are currently 20 aircraft in the country. Another important Israeli program, Peace Fox, provided for the purchase of 25 F-15 aircraft in prior years and another 15 for delivery beginning in August 1981.

The Iranian FMS program was the largest program in the ILC until the 1979 Islamic revolution. The total program value was $3.2 billion. Spares and support equipment are being held in the Iranian aggregation account at Hill AFB, Utah. Items still on contract are being diverted and absorbed or shipped to the special inventory account for Iran. Net receipts from diversions are being returned to the Iranian Trust Fund.

Asia/Far East

The Republic of Korea Air Force program continues to grow in terms of FMS cases. The Korean program has 291 open cases with a dollar value of $1.3 billion and includes 18 dfifferent system sales and special projects.

Americas/Pacific

The SA program for the Taiwan Air Force (TAF) is composed of both GA and FMS. The Peace Tiger program for the co-production of the F-5E/F is being accomplished by the Aeronautical Industry Development Center in Taiwan in conjunction with the Northrop Corporation. The co-production began in 1973 and will continue through 1985.

NATO/European

One of the SA programs for the German Air Force is pilot training in the US. For these training programs, the USAF provides instructor pilots, office space, living quarters, maintenance, supply, base supply functions, and medical care.

In addition to the United States, four European Participating Governments have joined in a multinational program to co-produce F-16 aircraft. They are Belgium, Denmark, Norway, and the Netherlands. The initial EPG program includes 348 aircraft valued at $2.8 billion in FY75 dollars. The Belgian program is for a total of 116 aircraft, 34 of which have been delivered. Beauvechain Air Base was activated in January 1979. Twenty-four of Denmark's 58 aircraft have been delivered and Skrydstrup Air Base was activated in January 1980. Norway's program provides for 72 aircraft, with delivery of 17 aircraft completed. Rygge Air Station was activated January 1980. Bodo Air Station was activated in April 1981. The Netherlands is purchasing 102 aircraft, 36 of which have been delivered. Leeuwarden Air Base was activated in June 1979. The Netherlands has initiated an additional purchase of 111 aircraft, with delivery over a five year period, starting July 1984.

(Ms. Claire Dieckman, ILC/XRXP, AU 787-6037)

℞

READER EXCHANGE

From the initial establishment of the AFJL, *there was provision to include this "Reader Exchange" feature on a regular basis if enough letters to the editor were received that addressed other aspects of issues raised in previous articles. During the past year, most reader correspondence has requested subscription/distribution information or expressed satisfaction in seeing the* AFJL.

Naturally, we have been glad to get the positive feedback. But the battle has been long and hard to establish the few pages available in the AFJL *to address substantive logistics topics (and that limited space every quarter does not begin to cover the full range and depth of logistics issues and subjects). Thus, we have intentionally chosen to give first priority to the major articles and the hard information in the other departments and major command items of interest.*

Yet, this reader forum is needed for several reasons: to provide for a wider professional dialogue among Air Force logisticians, to allow for further insight in and the surfacing of counterpoints to those issues and ideas published earlier in the AFJL, *and, in general, to enable readers to prescribe for the health of logistics and the* AFJL.

To establish this ℞ feature in the AFJL, *the following letters and some of the comments received in response to the reader survey are published below. The survey cards are still coming. Full results will be published in the next issue.*

Missing Transporters

Your article on Career and Personnel Information in the Spring 1981 issue omitted any reference to 60XX transportation authorizations; probably just an editorial slip. We transporters know that our career field is key to any successful logistics activity and that there is ample opportunity for senior executive assignment within transportation. Still, your other readers might not know and the article should have mentioned the career opportunities transportation offers.

Maj James E. Etzel
Executive, D/Transportation,
DCS/Logistics
HQ USAF

The omission was inadvertent. Transportation authorizations were considered in compiling the figures included in the article. Transporters will be especially interested in the announcement on page 12 about the occupational survey planned for transportation later this year.

"Munitions Logistics"

We particularly enjoyed Colonel Johnny E. Cormier's article, "Munitions Logistics," in the Spring 1981 issue of the Journal. We request your permission to reprint 20 copies of the article for distribution to planners, operators and logisticians throughout PACAF.

Lt Col Jerome A. Frisch
Asst Dir of Munitions, DCS/Log
HQ PACAF

Done.

Initial Reader Survey Comments

Should provide point/counterpoint to deal with different sides of issues.

Company grader (Supply)

A perspective column, an open "In my opinion" section. Let AF logisticians unload their ideas.

Company grader (Plans/Programs)

This is it. Read on.

General Comments

The *AFJL* is well done and of excellent quality. It is, however, one of those publications that is received by the Executive office and circulated to the staff in "ho-hum" context. It is not used, except for casual reading. Believe if discontinued, no one would notice.

USAF GS 13–15 (Multiple Fields)

AFJL is always a pleasant surprise to receive. Good material. A professional magazine worth the effort.

Field grader (Resources Management)

Layout/type should move toward those of the *Army Logistician*. *AFJL* was long overdue. Keep up the good work.

Non-DOD GS 9–12 (Supply)

Often seems to be a self serving school publication.

Company grader (Maintenance)

"Career and Personnel" section is great. Expand.

Company grader (Maintenance)

Too many technical viewpoints which encompass technical jargon—lighten the text.

Senior NCO (Multiple Fields)

Enjoyed Colonel Cormier's article ["Munitions Logistics", Spring 1981] and method of presentation.

Senior NCO (Maintenance)

The *AFJL* has been in publication longer than I have been in logistics; my opinion is based on gross inexperience. However, any publication that "spreads the word" for the sake of knowledge is well worth the effort, especially in the area of logistics.

Company grader (Transportation)

A little corner of the world for LCCEP, OCPO's super program for career logisticians. *AFJL* is more scholarly than ________ and more readable than ________.

USAF GS 9–12 (Supply)

Publish more often (6 per year) but only if you get quality articles. Overall I like the journal.

Field grader (Multiple Fields)

I would like to obtain the first four issues.

Industry (Retired 0–4) (Plans/Programs)

Would like to be able to obtain all of the back issues.

Industry civilian (Plans/Programs)

To keep printing costs down, each issue of the AFJL *is printed in only enough copies to meet current known distribution requirements. Reference copies are available in Federal Depository Libraries across the country. The major contents of every issue are also available through the Defense Logistics Studies Information Exchange, Ft. Lee, Virginia 23801.*

Suggested Future Coverage

More detailed comments on career progression, retention, opportunities for logistics managers. Excellent tool to inform reader on career opportunities and "how goes it."

Field grader (Maintenance)

More tutorials on AF logistics.

Industry civilian (Systems Acquisition)

As an LCCEP member I would like to see regular articles on cadre positions of all types. Articles should give enough data, dates, locations, etc., to be useful in planning careers. Cover international, acquisition and materiel management logistics every issue.

USAF GS 9–12 (Systems Acquisition)

More items applicable to unit level Log Planner.

Company grader (Multiple Fields)

Increase maintenance and overall logistics topics.

DOD GS 13–15 (Multiple Fields)

More articles on: FMS support—repair parts, pros and cons on blade/vane rebuild and on sources of supply.

Industry civilian (Supply)

Career information for junior officers.

Company grader (Munitions supply)

Most articles address logistics from the top looking down. It may pay to afford some effort to logistics from the bottom looking up. This may help top management recognize grass roots operational problems created by gaps in the current systems.

USAF GS 9–12 (Contracting)

Articles should include 30XX officers and 30XXX enlisted. We are maintenance people too. Ground C-E equipment seems to be ignored.

Company grader (Maintenance)

More articles on deployment/mobility, load planning, lessons learned/crosstell . . .

Field grader (Multiple Fields)

How about an article on implementation of AFR 80–5 ["Air Force Reliability and Maintainability Program"]? Would be very timely. Keep up the good work.

Industry civilian (Multiple Fields)

Applications in business and industry of technology applicable to Air Force activities.

Municipal government employee (Multiple Fields)

More on operational logistics such as maintenance at base/depot level, deployments, readiness and mobility programs. Research is covered well.

USAF GS 13–15 (Multiple Fields)

Munitions topics.

Company grader (Distribution)

To prospective AFJL *contributers: if you are willing and able to add to logistics knowledge in any of the above areas, sharpen your pencils and send us a manuscript for consideration. There is very clearly a large group of professionally interested logisticians out there.*

To current AFJL *readers: Keep reading. The* AFJL *will continue to include something in each issue of interest to as many parts of the* diverse *logistics community as possible.*

Comments intended for this department should be addressed to Reader Exchange, AFLMC/JL, Gunter AFS, Alabama 36114. Letters must be signed; but, if requested, names will not be published.

Information for Contributors

General. The *Air Force Journal of Logistics* is dedicated to the open examination of all aspects of issues, problems, and ideas of concern to the Air Force logistics community. Constructive criticism of logistics as it exists today is encouraged if it is issue oriented, rationally expressed and indicates the positive action necessary for future improvement. Contributions are welcome from any source inside and outside the Air Force.

Scope. The *AFJL* will consider for publication articles and research results that add to the understanding or improvement of any aspect of Air Force logistics from maintenance, supply, transportation, and logistics plans, to engineering and services, munitions, and contracting and acquisition; from base-level and operational units to depot-level and military and civilian industrial and production logistics; from logistics civilian, enlisted and officer personnel and manpower requirements to training and education; from internal organizational structure, policies and procedures to external relations with other services, government agencies, civilian industry and allies; from daily mission support challenges to the logistics aspects of national security objectives and Air Force strategy, doctrine and tactics.

Special Interest. Articles are especially invited that:

- give the results of the application of sound analytical and research techniques to existing Air Force logistics operations;
- offer possible alternatives to current operations based on a logical assessment of today's posture and tomorrow's requirements;
- demonstrate the interrelation of various parts of Air Force logistics systems internally and with non-USAF systems;
- consider basic Air Force logistics functions and issues from an unusual perspective;
- focus on logistics and Air Force mission accomplishment;
- or, provide insight into the reasons for and impact of recent or future changes in Air Force logistics.

Original Material and Revisions. Submitted articles are received with the understanding that:

1. They have not been published nor are being considered for publication elsewhere. Articles based on research planned for publication *only* as an in-house report or in symposium proceedings are acceptable.

2. Those articles with multiple authors have been approved by all. The *AFJL* will work with the lead author in preparing the manuscript for publication with the understanding that any approved changes are acceptable to all.

3. To the greatest extent possible, necessary revisions in the manuscript will be coordinated with the author.

Length. In general, manuscripts should be between 2000-3500 words. Shorter and longer papers may be published on an exceptional basis. Formal research papers should briefly recognize the most significant research accomplished in the area of investigation and the relation of that research to the work addressed in the paper. A 50-75 word abstract should accompany each manuscript.

Format. Manuscripts should be typed with one inch margins, double-spaced on one side of standard size bond paper. References should be numbered and double-spaced on a separate page(s) at the end of the manuscript. The double number system for identifying references within the article should be used, i.e., (7:15), with the first number identifying the number of the source in the reference list and the second number indicating the specific page number in that source. When possible, potential textual footnote material should be incorporated in the main body of the article. Do not include a separate bibliography.

Figures and Tables. Supporting figures, if any, should be numbered consecutively and prepared on separate pages, one to a page. The text should clearly indicate where each figure is to appear. Tables should be numbered consecutively and be prepared within the appropriate text of the manuscript.

Awards. Published articles are eligible to compete for the Most Significant Article Award in each issue. The quarterly award winners will compete for the annual award from the *AFJL*. Selection is made by the members of the *AFJL*'s Editorial Advisory Board. Articles published by the Editorial staff, Contributing Editors, and Editorial Advisory Board are ineligible for the awards.

Reprints. Permission for schools and other publications to reprint material appearing in the *AFJL* will usually be granted, if requested.

Address. All correspondence and manuscripts should be sent to:

Air Force Journal of Logistics
AFLMC
Gunter AFS, Alabama 36114

Telephone: AUTOVON 921-4087
Commercial: (205) 279-4087

"The art of war teaches us to rely not on the likelihood of the enemy not coming, but on our own readiness to receive him; . . ."

(Sun Tzu, circa 500 B.C.)

Air Force Journal of Logistics
Air Force Logistics Management Center
Gunter AFS, Alabama 36114